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THE LAWS OF MOTION.

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How does a body behave when the forces which act upon it are balanced? It either remains stationary, or, if it is moving, it continues to move with unchanging velocity along a straight path. Conversely, if a body is stationary or if it is moving with unchanging velocity along a straight path the forces which act on the body are balanced.

When a mule draws a canal boat steadily along a straight canal the forward pull of the mule on the boat is equal to the backward drag of wind and water on the boat. This is a simple matter of fact, and yet there probably never was a canal-boat man who could be made to believe it. It costs so much to feed a mule and it takes so much trouble to drive the animal that no canal-boat man can think of the costly pull of the mule as equal to the backward drag of wind and water. In certain very important respects the pull *is* different from the backward drag, because the mule is doing work, but pound for pound the pull of the mule certainly is equal to the backward drag when the boat is moving steadily along.

How does a body behave when acted upon by an unbalanced force? Imagine, for example, a body which is acted on by one force only; such a force would be an unbalanced force, and the body would gain velocity in the direction of the force at a rate proportional to the force and inversely proportional to the mass of the body.

We often, of course, put this question to young men and we find that the natural habit of thinking-in-terms-of-human-values shows itself in spite of the most exacting class-room drill. Instead of focussing his attention narrowly to *what is taking place at a given instant* a young man, in his groping for human

values (which do not exist in the bare elements of science) is pretty sure to refer to past history and future prospects; his idea as to what *is taking place* is apt to remain widely inclusive as if he were thinking of a complex human experience like two hours at a play or a month's vacation. Very often the homely wording of the question as stated above betrays the young man into a disclosure of his native contempt for precise ideas and he answers naively that "The body moves in the direction of the force." It is very difficult to develop the habit of analytical thinking.

EQUALITY OF ACTION AND REACTION.

It is safe to assume that many of the readers of SCHOOL SCIENCE AND MATHEMATICS who know and understand many complicated things in physics do not really understand the principle of equality of action and reaction. The question for testing this matter is "Considering that forces always occur in pairs, action and reaction, which are equal and opposite, how is it possible to have an unbalanced force act on a body?" or the question "If action and reaction are equal and opposite why do they not balance each other?"

Let us consider the latter question first. If I am \$1000 in debt and you have \$1000 saved up. Why does not your savings balance my debt? The simple answer, which is greatly to your discredit, as it seems to me, is that the debt is mine and the savings yours! To balance each other two forces must act on the same body, and action and reaction always act on different bodies. As I sit in my chair I push downwards on the chair, and the chair pushes upwards on me.

Iowa is north of Missouri—yes, but Missouri is south of Iowa! He who would argue that an unbalanced force acting on a given body *cannot be* because action and reaction are always equal and opposite would take rank as a thinker with the purist in speech who would wish to invent a fancy way of saying that Missouri is *south* of Iowa, fearing a verbal battle with the man from Missouri who knows that Iowa is *north* of Missouri! Imagine a man who in considering that *A* is north of *B* argues that *B* is the same distance south of *A* so that nothing can ever be really north or south of anything. The geometric sense of such a man would be on a par with the mechanical sense of a man who would conclude that an unbalanced force cannot exist because action and reaction are always equal and opposite or

on a par with the business sense of a merchant who would cancel a debit against John Smith because this debit stands as a credit in his personal account in John Smith's set of books.

Equality of action and reaction has nothing whatever to do with the question of balance. A set of forces which balance each other must all act on the same body, and, although each force of the set is accompanied by an equal and opposite reaction, these reactions are forces which the given body exerts *on* other bodies. The set of forces which act on the given body are exerted by other bodies and the reactions are the forces exerted by the given body on the other bodies.

The force action between two bodies *A* and *B* is really one single thing (a stress, let us call it); and yet if we are chiefly interested in body *A* we must think of this thing as a force exerted by *B* on *A*, and if we are chiefly interested in body *B* we must think of this thing as an equal and opposite force exerted by *A* on *B*.

RICHEST COPPER DEPOSIT.

The romance as well as the scientific and technical aspects of metal mining is set forth in a recent publication of the Geological Survey of the Department of the Interior, entitled "The ore deposits of the Jerome and Bradshaw Mountains quadrangles, Arizona." The area includes the famous United Verde and United Verde Extension mines, as well as many that are smaller and less well known.

The first discoveries of placer gold in this region were made in 1863, but they did not prove profitable. Beginning in 1875, many rich gold and silver bearing lodes were found, and by 1885 many of these were exhausted, although others were productive until 1905. The United Verde deposit was worked for silver about 1880, but the value of the copper output soon exceeded that of the silver, and it is now the richest deposit of pyritic copper ore in the United States. Since 1900, the dividends paid by this mine have exceeded \$63,000,000, and although 2,500 feet deep, it will probably be very productive for many years. The United Verde Extension ore bodies near by, discovered in 1915, have been highly productive, and to date over \$20,000,000 in dividends has been paid by this mine. Both mines are in bodies of copper-bearing pyrite. The production of the mines of this group to date has amounted to about \$130,000,000.

The other metal mines of the area are in simple veins containing gold, silver, copper, lead, and zinc minerals. Some of these have been worked at considerable profit and have been explored to 1,000 or 1,500 feet below the surface. Many others have shown steady decline in grade at less depth. In some a sharp decline in the yield of gold and silver took place at water level, 100 to 400 feet below the surface, and it is concluded that the upper zone has been enriched during erosion.

Tables are given in the report showing the details of annual production of the metals since 1900 for each of the 15 or more districts in the area described. The total value of all metals produced to the end of 1923 is estimated at about \$300,000,000.—*Science Service.*

PRESENTATION OF CONTOUR MAPPING.*

BY VIVA DUTTON MARTIN,

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The importance of being able to use maps intelligently is becoming a matter of urgent importance in these days of promiscuous travel by the masses.

Until quite recently, if one wished to travel he purchased a ticket, boarded a train under supervision, and was put off at his destination by the conductor. No knowledge of maps was necessary for even extended traveling by this method. But now the whole family gets into an automobile and starts out on the highway to travel, with the entire responsibility of finding the way to their destination resting with the occupants of the car. This situation adds another responsibility to the school—to educate the coming mass of citizens in the intelligent use of maps.

The contour or topographic map, with the completeness of its presentation of detail, could be the most useful of all maps to travelers if they could only understand reading these maps.

From the point of view of the class room teacher of Physiography or Geology other important considerations are added to make it desirable to present contour mapping in such a way that the pupil gains a thorough, usable understanding of them. Travel on the maps in laboratory work gives the best possible substitute for real field work. In the experience of the writer, the time spent in gaining a working understanding of topographic maps has more than paid for itself in the increased understanding of the pupils of the nature of various features of relief and their relation to each other. Such conceptions are especially poor among children living in a large city, as is the case with the author's pupils.

The average high school text book, and college too, presents more facts about the conceptions involved in contour mapping in one or two brief paragraphs than can be grasped by the average student in two weeks of careful presentation.

The following method of presentation of contour mapping aims: (1) to present a small enough unit each lesson to be easily and completely grasped by each student (2) to have each lesson involve all of the principles learned up to that point (3) to permit

*Read at the Geography Section of the Central Association of Science and Mathematics Teachers, Chicago, Nov. 26, 1926.

each student to work as rapidly as his comprehension permits. No pupil is permitted to advance to the next lesson until every detail of the lesson in hand has been mastered.

For the initial presentation a model made of clay, still soft, is used. The model is of an island, generally conical in shape with a base about 10 inches in diameter and a height of $4\frac{1}{2}$ inches. The top of the cone is considerably to one side of center in order to develop different slopes down the sides. A valley extends from the top in a curved direction down the gentlest slope to the base. When the demonstration begins the model is without contour lines. These are drawn before the students in order that they may gain the fundamental conception of the contour line, the contour interval, and the intercontour space. The contour lines are drawn on in the following manner. A block of wood $\frac{1}{2}$ inch thick, 5 inches wide and 7 inches long is placed beside the model. On this is placed a thin piece of sheet metal larger than the block, with edges shaped into the various curves most frequently seen on contour lines. The piece of sheet metal is kept flat on the block and pushed along the block until it touches the model where it leaves the imprint of a line. The block is moved about the model and this process continued until a contour line has been imprinted entirely about the island. Then a second block, identical to the first, is laid on top of the first, and the marking process is repeated to draw the second contour line. Then a third block is added and so on until the entire model has been contoured before the class. The use of the blocks emphasizes the fact that all points on the contour line are the same perpendicular distance from sea level, regardless of surface appearance; and the addition of similar blocks as higher lines are drawn makes clear the important principle that every contour line on a given map is the same perpendicular distance from the previous line. As the lines are being drawn on the model, attention is called to the variation in the width of the intercontour spaces. By the time the last line is drawn each individual has a clear idea of the relationship of intercontour spaces to slope. When the lines are all drawn, the model is tilted so that the class can look straight down on it and get the correct conception of the point of view from which all contour maps are made.

The first exercise in the laboratory aims to instill the principles presented in the presentation demonstration. A number

of other clay models, enough so that not more than four students have to work at one model, are provided. These models are about the size of the demonstration model, which is also used, and represent simple features of relief as: two hills of different height with a valley between; two hills, of different heights, with a valley between and a tributary valley down the side of one hill; a plain with one main valley and a single tributary; a rougher plain with one main valley with two tributaries. These have all had contour lines drawn on them at $\frac{1}{2}$ inch intervals the same as the demonstration model. Each student then makes a drawing the full size of a sheet of drawing paper, of the contour lines on one of these models. After the drawing is correct in principal details, it is Okayed by the teacher, and the pupil receives a set of questions to which he writes the answers to accompany his map. These questions call his attention to the steepest slope, the gentlest slope, the greatest intercontour space, the smallest intercontour space, how the contour lines are drawn to show a valley, a ridge, a hill; how to tell the bottom, the width, and the slope of a valley from contour lines. He is encouraged to consult the model as well as the map in answering these questions to increase his appreciation of the relation of the two to each other.

Each student makes a drawing of two models and writes the answers to the accompanying questions. If a student does not show a sufficient mastery of the detail represented up to this point, he draws a third model, and even a fourth if this seems necessary.

After the models have been thus mastered, a section line is drawn by the teacher on one of the two maps of the student and he is given printed directions for the drawing of a cross-section along this line. The drawing of a cross-section becomes very simple and comprehensible when the model can be consulted to see the ups and downs along the section line. When the first section has been perfected, a second section is drawn from the other drawing of a model which the student has made.

By this time the student should have his fundamental concepts of the relation of the shape of contour lines and the width of intercontour spaces to relief. He is now ready to learn some of the conventional details of a map.

His next exercise is to read the explanation of contour maps as given on the back of a U. S. topographic map and to look at the map itself (his first sight of a real contour map) with

emphasis on learning (1) the contour intervals used, (2) the scales used and their meaning, (3) where each of these items are placed on the map proper and in what form expressed, (4) the convention of the numbering scheme of the contour lines.

When he says he has mastered this, he is given the following exercise:

Contour Map of a Symmetrical Island.

Draw a contour map of a conical island six miles in diameter at its base and 2031 feet in elevation. Horizontal scale, 1 mile = 1 inch. Contour interval 200 feet.

If, when the student presents this exercise, every conventional detail as well as the fundamental conceptions of representing the relief, is not correct, no comment is made by the instructor, but a check is placed at the bottom of the paper and the student is advised to read and study a contour map some more. This process is repeated until the map is perfect in every detail, then it is graded on a basis of the number of checks on the sheet. If the pupil totally fails in a conception of the relief, he is provided with Pasteline and required to make an actual model of the island and mark off the contour lines on the model by the aid of a ruler and a toothpick.

A section line is drawn across the contour map of the island and a printed sheet of such additional instructions as are necessary for drawing a cross-section from a real contour map is given the student. He then draws the cross-section indicated.

The next exercise is a plain with one valley through the center of it. The same method of procedure is followed as in the case of the island. The third of this series is an exercise of two hills with a valley between them.

If the student has done well on these three he progresses another step; if he has not, he receives further exercises of similar difficulty but different figures, until he masters the details involved up to this point. It is to be noted that the exercises up to this point are identical in principle of relief with the models. A student having difficulty with conceptions of relief is referred to the model illustrating the point.

The next assignment for the student is to study the symbols used on a contour map, both as represented on the back of the map and on the map itself. He is asked to make a drawing of the twenty symbols used most often, a list of these is provided, and beside each to indicate the color used for that particular symbol.

The pupil is now ready to draw not only the contour lines of a map but to put on topographic symbols. A series of exercises combining these features are now presented. The student who does well, draws two of these maps; more are required if he does not do well. If the pupil is weak on cross-sections, he is required to draw sections of these maps also.

Reading of elevations from the actual topographic maps is next in order. A brief oral explanation is made of how elevations are read. Then the student is given an exercise to read the elevation of the points indicated. Following is a portion of such an exercise:

ANTHRACITE SHEET, COLORADO.

Read the elevation of the following indicated points.

1. Carbon Peak, southeast part of the map.
2. Three houses at Kubler Mine, southeast corner of map.
3. Bank of Clidd Cheek where it leaves the map.
4. Top of Prospect Point, northwest part of map.

Points incorrectly read are checked and the student tries again. This is repeated until all readings of one exercise are correct. Then the student proceeds to the next.

Each student reads elevations (10 to 16 on a map) from five maps. If this art of reading elevations is not then mastered, more elevations on different maps are read. The maps for these readings are very carefully selected so that no two have the same contour interval and so that as many Physiographic Provinces may be represented as possible in order to broaden the student's experience with maps. This practice in reading elevations gives very valuable training in (1) recognizing various features of relief, (2) in recognizing symbols on the map, (3) in understanding slopes, changes in slope, and other finer matters of map interpretation. If time can be afforded to work more on this step, it will bring rich returns.

At the end of this series of exercises the student should be able to read and interpret a contour map intelligently and be able to see on topographic maps illustrations of the work of rivers, volcanoes, glaciers, or whatever part of the subject is being discussed in the recitation.

A "technical attaché in public instruction" has been added by the Cuban Government to its embassy in the United States. The duty of this official is to keep his Government informed concerning educational progress in this country, especially in practical and specialized educational work.

ILLINIUM.

By L. F. YNTEMA,
University of Illinois.

This report is based on the original publication by B. S. Hopkins, J. A. Harris and the writer, appearing in the *Journal of the American Chemical Society* 48 1585-98 (1926).

Since the publication in 1913 and 1914 of Moseley's¹ atomic number rule there has occurred a renewed interest in the search for unknown elements. The periodic classification of Mendelejeff had showed that many elements were missing and chemists took up the search for elements to fill the empty spaces in the table. The difficulty that confronted the investigator was the necessity for identifying an element by means of properties, chemical or physical, that could be only approximately foretold. Only when a body was found to possess properties differing from those of any known body, could the presence of a new element be assumed. The long list, once announced and since disproven, shows how many mistakes were made in interpretation of data. Moseley's work opened a path of procedure that avoids all the pitfalls awaiting the earlier chemist—although others are opened up. He pointed out that there is a strict relationship between the X-ray spectrum of an element and its atomic number. Subsequent study of the X-ray of all known elements showed that, in the sequence of atomic numbers, one to ninety-two, only five were missing; numbers 43, 61, 75, 85 and 87—assuming that Urbain² had identified element number seventy-two in his rare earth material.

X-ray spectroscopy, as a means to identifying unknown elements, besides indicating which are missing, offers a basis for the calculation of the wave length of the several X-ray lines of an unknown element, gives a method of examination so searching that a mixture of two elements, so closely similar in chemical properties as to be almost inseparable, may be definitely analyzed. For this reason X-ray analysis is especially applicable to the search for number 61, the missing rare earth. As far as I know, Urbain and Dauvillier³, first used this means of identification when they published their findings on the X-ray spectrum of element seventy-two.

¹Moseley. *Phil. Mag.* (6) 20 1024 (1913); (6) 27 703 (1914).

²Urbain. *C. R.* 152 141 (1911).

³Urbain and Dauvillier. *C. R.* 174 1347 (1922); 174 1349 (1922).

The rare earth group of sixteen members occupies a peculiar position among the elements and seems to have been the source of a lot of annoyance to scientists in their efforts to improve on Mendelejeff's periodic arrangement. The best disposition of the group seems to be to put them all in the space in Group III, Series 5, usually assigned to lanthanum. They are a group of elements that always occur together, and are so similar in chemical and physical properties that the methods of separation applied to the more common elements are useless. The only elements offering comparable difficulties are the platinum metals in Group VIII. The striking similarity among the rare earths may be understood if their comparative atomic structures are considered. The two outer electron shells or orbits, the 5th and 6th, have the same number of electrons for all the rare earths, the only change being in the 4th, where one electron is added to each successive member of the group. With such a slight difference in atomic structure it is to be expected that the properties of the group will be almost identical. The two most useful methods of separation are fractional crystallization, which depends on slight differences in solubility of compounds, and fractional hydrolysis, which takes advantage of slight differences in basicity.

Rare earths are not as rare as their name would indicate. They are found in a large number of minerals in various parts of the world. Probably the most important source is in monazite sands, a rare earth phosphate found in Brazil, Ceylon, India and in the United States. This mineral is mined for its thorium and cerium, used in the manufacture of Welsbach gas mantles and for its mesothorium. When these have been removed, the residue is considered as waste material. Another mineral is gadolinite, found in the Scandinavian Peninsula and in this country. These two minerals are respectively typical of two general classes: one, the cerium sub-group minerals that contain a large proportion of the cerium sub-group, the rare earth elements of lower atomic number, and the other, the yttrium sub-group minerals that contain more yttrium and earths of higher atomic number. While the proportion between the relative amounts of the sub-groups may vary in different minerals, it has been found that the relative amounts of the members of either sub-group is about constant. Thus neodymium is always present in larger amounts than europium. This comparative rarity of

some of the rare earths was an important factor in the search for number 61.

The proof given by Moseley's work, that a rare earth element was missing whose atomic number would place it between neodymium and samarium, explained the sharp break in the sequence of properties that comes between these two elements. There is a break in the sequence of solubilities of salts, in basicity, as indicated by the rate of hydrolysis, in the formation of hydrides, and in numerous other properties.

Because element number 61 might be expected to share the striking similarity in properties and the common occurrence in minerals of the other members of the rare earth group, it seemed logical to institute a search for it in monazite sands. Since that mineral is rich in neodymium, 60, and in samarium, 62, it would be surprising to learn of the absence of 61 there and its presence in a mineral containing little or none of 60 and 62.

The original material used in the investigation was the rare earth residue remaining from monazite sands after the extraction of thorium and part of the cerium for the manufacture of Welsbach gas mantles and after the extraction of the mesothorium. The remaining cerium was first removed by oxidation with potassium permanganate and the other rare earths were then fractionally recrystallized as double magnesium nitrates in which the members of the group separate in order of their atomic numbers, the lowest, lanthanum, 57, being the least soluble.

The first indication of the possible presence of 61 in the material was the result of an investigation published by Kiess⁴ and others at the Bureau of Standards, at Washington, D. C. The University of Illinois furnished the Bureau with samples of neodymium, purified as described above, and samarium, which had been subjected to further purification by other methods, for use in an extensive investigation being pursued on the infracted arc spectra of the rare earths. It was found that a number of new identical lines were present in both samples and the suggestion was made that they might be due to the presence of a new element. Eder⁵ had noticed the same phenomenon. This was the information at hand when the problem was taken up by the present authors.

First the ultra-violet arc spectra of neodymium, samarium,

⁴Kiess. *Bur. Standards Sci. Papers* 442 (1922).

⁵Eder. *Sitzb. Akad. Wiss. Wein. II A*, 125 (1917).

and of intermediate fractions containing both, were found to show a few identical lines, which appeared strongest in the mixtures of the two elements. X-ray analysis of these same preparations showed no indication of the presence of an element with an atomic number 61, unless it were present in a ratio of less than 1 in 1000, which was the limit of delicacy of the X-ray apparatus.

In the fractionation of the double magnesium nitrates, in which the solubility increases with increasing atomic number, the separation of 61 might be expected to be difficult because of the relatively large proportion of 60, neodymium. Furthermore it seems probable, from later knowledge, that the solubility of the 61 compound is quite close to that of the neodymium compound. It is a matter of experience that an element present in a small amount may be separated rather easily, if its solubility is less than that of its more plentiful neighbor, while if its solubility is greater, the separation is very difficult. These considerations suggested fractionation as bromates, in which series the order of solubility of the cerium group elements is reversed. Thus if a fraction in a double magnesium nitrate series, containing a little samarium and a large percentage of neodymium, is converted to bromates, further fractionation will separate samarium and 61 in the insoluble end of the series.

One of the most convenient methods of analyzing a mixture of rare earths is examining the absorption spectrum of the solution. Since both 60, and 62 are colored earths and have characteristic absorption spectra, it might be expected that 61 would exhibit similar properties. The bromate series were under constant observation by this method of analysis and it was noted that absorption bands at 5816\AA and 5120\AA formerly supposed to be weak neodymium bands were increasing in intensity in certain fractions while the more characteristic neodymium bands were disappearing in the same fractions. It has been pointed out that there is a regular relationship between the position of a characteristic absorption band and the atomic number of a rare earth and the band at 5816\AA has the value called for by element 61. Furthermore the band at 5816\AA and another at 5120\AA appeared in those fractions in which solubility considerations indicated 61 might be present.

The fractions in which these two absorption bands were the most prominent were subject to X-ray analysis and the preparation was found to emit X-rays of the calculated wave length for

61 $L\alpha_1$, and $L\beta_1$. The values 2.2781\AA° and 2.077\AA° are in good agreement with the theoretical values and it seems improbable that any other element that would interfere was present.

The conclusion that element 61 was present is founded on the presence of new lines in the arc spectrum; on the appearance of absorption bands in the preparations that might be expected to contain 61, which bands have wave lengths such that they fit into a regular order; and finally on the discovery of two lines in the L series of the X-ray spectrum. The name illinium and symbol Il have been assigned to it.

The search for the element has been in progress in several laboratories. Prandtl and Grimm⁶ reported in 1924 that they could find no trace of the element after fractionation as double magnesium nitrates. Druce and Loring⁷ examined manganese materials for presence of the element but found none. Meyer, Schumacher, and Kotowski⁸ concentrated the element by fractionation as bromates and then as double magnesium nitrates with the addition of double magnesium-bismuth nitrate. They identified the element through the presence of lines in the K series. Rolla and Fernandes⁹ fractionated their material as double thallium, ammonium, and magnesium nitrate. They noted absorption bands in the yellow portion of the spectrum. They identified lines in the L series and the K absorption limit. It is of interest to note that the element was discovered independently by three groups of investigators at about the same time and that very similar methods of separation and identification were employed.

⁶Prandtl and Grimm. *Z. anorg. Chem.* 136 283 (1924).

⁷Druce and Loring. *Chem. News* 131 273 (1925).

⁸Meyer, Schumacher and Kotowski. *Naturwiss.* 17 771 (1926).

⁹Rolla and Fernandes. *Gazz. chim. ital.* 56, 435 (1926).

ANTI-EVOLUTION IN ARKANSAS.

The battles of Tennessee, Mississippi and other Southern states are to be fought over again in Arkansas this winter, according to the *Baptist Advance*, a Fundamentalist publication of Little Rock. While denying the possession of any inside information, the Baptist journal says:

"It is our opinion that a bill will be introduced and passed by the next legislature prohibiting the teaching of evolution (as commonly understood) in the state schools of Arkansas. We believe absolutely that such a bill ought to be passed and we think it likely that it will meet very little opposition if it is drawn in a sensible form."¹

The editor states that it is his belief that 99 per cent of the preachers of Arkansas and an overwhelming majority of the voters are in favor of such a law.—*Science Service*.

**TEST CONSTRUCTION IN LESS STANDARDIZED SUBJECTS
ILLUSTRATED BY THE RICHARDS BIOLOGY TEST.¹**

BY OSCAR W. RICHARDS,

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Biology is one of the studies which cannot be standardized at the present time and probably should not if the most is to be gained from its wide and varied content. The type of course that is best adapted to the students in the large city is not the same as that adapted to the two-room country high school. Then again teaching methods differ widely. One excellent teacher follows the plan of teaching according to the needs of the community; another teaches the content of his course thru the study of the functioning of the organisms mentioned and an equally successful teacher lets the student learn biology as he examines representative plants and animals of the several phyla. A teacher who teaches biology by considering mainly energy changes has students who do especially well in the state university.

There are certain principles and facts of biology that most teachers feel should enter into all courses and be presented by all methods. Yet, certain biology teachers in the same city would debate all but a very few of these. Consequently the pedagogical test to measure achievement in biology must measure all courses and cover more than the few generally accepted principles if the test is to be useful to the teacher.

Time would not permit some qualified person to visit all of the schools wherein biology is taught to determine just what the content of their courses is even if money for this were available. This person would have to estimate the teacher from a knowledge of his or her training and experience as well as the outline of material taught in order to obtain an adequate knowledge of what constitutes high school biology in the United States. The next best way of obtaining this knowledge is to investigate a sample of schools. This was done by sending a questionnaire to the school superintendents of all cities of over 100,000 population. After using three follow up letters replies were received from 86 per cent of them.

These replies showed the wide variety of the courses taught as biology and the fact that on the whole the courses were adapted to the needs of the community that the school served. This

¹Aided by a grant from Chi Chapter, Phi Delta Kappa.

information has been summarized and published in another place.^{2,3} From these data it was obvious that a satisfactory test in biology must cover much more material than was actually taught in any given school system and that when the test is to be used for purposes of diagnosis the diagnosis must be based on those parts of the test which measure the subject matter actually taught. One teacher emphasizes the naming of plants and animals according to the classification scheme and another teacher teaches almost no classification and they may both serve their particular needs well. In order that the test may serve all needs it must cover the sum of both their courses and each one only needs to use those items which pertain to his course. The pedagogical soundness of this theory is more apparent when we see test constructors in the more standardized subjects, such as arithmetic and algebra, at present reconsidering their fundamental content.

Some of the courses in these larger cities followed their own outlines, others a particular text. It was found further that six of the textbooks reported represented about 80 per cent of the courses. These books undoubtedly represent more than eighty per cent of the biology courses when we recall that the smaller schools depend more on the text. These six books are: Bergen and Caldwell, *Practical Botany*; Hunter, *Civic Biology*; Hunter, *Essentials of Biology*; Linnville and Kelley, *General Zoology*; Gruenberg, *Biology*; and Peabody and Hunt, *Elementary Biology*.

The content of these books was analyzed by topics and according to the amount of space given.³ This sample is fairly representative of the material covered in high school biology and was used in constructing the Richards' Biology Test.

The form of the test must then be considered. It was decided to use the multiple response type as more of the students' knowledge could be sampled during a 40 minute high school period. This type also permitted the use of a stencil to score the test. The tests may be readily corrected by clerical help as the answers do not require expert evaluation. The number of items then is limited numerically to a convenient number and to the length of time usually allotted to testing. One hundred items are easily marked by the students in a high school period and this number

²Richards, O. W. Present status of biology in the secondary schools. *School Review*, 1923. 31:143-7.

³Richards, O. W. Present content of biology in the secondary schools. *School Science and Mathematics*. 1923. 23:409-15.

permits expressing the scores as a percent. Since it has been indicated theoretically⁴ that the guessing factor of the four alternative type test is small enough that it may be disregarded in a test of one hundred items it was decided to use four alternatives to each item in this test. This seems more desirable when we see how inadequate the right-wrong method is⁵ and how much more accurate the four response is over the three response test.

The content of the Richards Biology test is divided into the following groups: Practical value, 24 items; Digestion, 14 items; Classification, 23 items; Interrelation of biology, 8 items; History of biology, 14 items; General biology, 17 items. These topics and items were chosen from the survey of the content of biology mentioned above. The test was then improved by the information gained from classes. The test was then submitted to several experts in test construction and in biological science as well as to a number of high school teachers and was further improved from their constructive criticism.

The test in its present form is not too difficult for high school students and yet sufficiently comprehensive for testing university freshman students of biology. The test covers reasonably well the field of biology and is therefore adequate to measure the knowledge of students in any given biological course. As soon as the students' scores are compared with the number of items on the course that were taught to him the test becomes diagnostic and indicates both the particular interests of the student and the effectiveness of the teaching. Students' interests vary and their knowledge usually varies with their interests. Certain students will answer most of the items in one part of the test correctly and miss half or more of the items in another part of the test. The breadth of the test is adequate to measure these individual variations. As will be seen from table I the highest high school score so far obtained is 72 and the highest university freshman score is 89.

TABLE I.
Scores Obtained with Richards Biology Test.

Class	City	Date	No.	Score		Low	\bar{x}
				High	Mean		
University High School	Eugene	1924	33	72	57.1	43	7.77
University High School	Eugene	1925	27	63	51.2	42	6.61
Jefferson High School	Portland	1924	71	70	51.4	29	7.39
Univ. freshman biology	Eugene	1924	56	84	60.6	15	11.16
Univ. freshman biology	Eugene	1925	116	89	63.3	40	9.86

⁴Richards, O. W., High test scores attained by subaverage minds. III. Jour. Exper. Psych., 1924. 7:148-57.

⁵Richards, O. W. and Kohs, S. C., High test scores attained by subaverage minds. II. Jour. Educ. Psych., 1925. 16:8-18.

The reliability of this test was determined by correlating the odd answers with the even answers and by comparing the scores made with the same class with the Richards and the Ruch-Cossman biology tests. Correlating the odd with the even answers gave $r=0.623\pm0.038$, using the data from the 1925 university freshman biology class. This class was used as it contained a larger number of students. If the data had been obtained from a less selected group of students the correlation would have been higher. By the use of the Spearman-Brown prophesy formula we find that the reliability is 0.77 based on the above correlation. Correlating the Richards test scores with the Ruch-Cossman test scores and correcting the coefficient for attenuation we find $r=0.707$.

If the Richards test scores are correlated with the grades the students received for the first two classes in table 1 and correcting for attenuation, we obtain $r=0.89$ and 0.66 respectively. For this correction the reliability of the grades was set arbitrarily at 0.6 . The probable error of the score is only 2.80 . The standard error of distribution for the classes is given in table 1.

The Richards Biology test may be favorably compared with the Ruch-Cossman Biology test, which is the only other standardized biology test. The average reliability of the Ruch-Cossman test is 0.82 and the probable error of the score is 3.1 points.⁶ The correlation of the grades received and the scores of this test with the University High School class gave a corrected value of 0.63 .

Directions for giving the Richards biology test are given in the manual that accompanies it and on the test proper. The scores are used as the number right. The groups are not weighted as the weight given would depend entirely on the content of the course tested. The probability of the student obtaining significant scores by guessing is sufficiently small to be ignored.

It seems to the writer than norms for the biology test must be merely statistical abstractions in which the very desirable individuality of the course designed for a given community becomes lost. Until there is an agreement by biologists as to what information is the minimum and until the course taught by each teacher is known it seems fruitless to attempt to compare the scores of one school with any other unless the courses are known to be the same. Therefore, the establishing of norms

⁶Ruch-Cossman Biology Test. Manual of instructions. World Book Co., 1924.

must be done for a particular course over a period of time by the teachers of that course. The whole problem of what constitutes an adequate norm and to what extent norms of one school may be compared with those of another school is one of the most important facing the test using part of the educational world at the present time.

Since the writer realizes that other teachers consider norms of greater value, certain tentative norms are presented in table 1. The teachers using the test are requested to send in copies of their tabulation sheet, which will be used in determining whether more general norms will be of value, and the data gathered will be published as soon as it is sufficient to warrant it. In the meantime it is hoped that this discussion will stimulate others to express their opinions on the extent that norms are justified in a subject whose content is as broad as that of biology and whose courses and methods must be especially adapted to the needs of the community that that course serves whether it be for the farm, the small town or for the children of the tenement districts of large cities which may be inland or on the seacoast.

In order that the reader can better understand this test the following samples are given to illustrate the makeup of the test.

RICHARDS' BIOLOGY TEST⁷.

Directions.

Below are some statements to test how well you know and can use the information that you have learned in your biology course. Each statement has four answers, but only one is a good biological answer. Look at all of the answers of each statement carefully and make a cross before the answer that makes the best sense.

Example.

- One should not use another person's toothbrush because it
 does not belong to him
 encourages other people to borrow toothbrushes
 X may carry disease germs
 will not fit his teeth

In this sample the third answer is marked with a cross because it is the best answer. Begin with number 1 and make a cross before the best biological answer to each statement. If you are not sure, guess.

Practical Value Questions.

- A. Mosquitoes should be killed because they
 bite us
 get into our food
 may carry malaria
 keep us from sleeping at night
 B. All forests must not be destroyed because
 we need the leaves, acorns and needles
 they are pretty
 we need the shade
 they save our water supply

⁷Published by C. H. Stoelting Co., Chicago, Ill.

Digestion Questions.

- C. Starch digestion produces
.....triose
.....maltose
.....arabinose
.....saccharose

Classification Questions.

- D. Turtles are
.....fish
.....mammals
.....amphibians
.....reptiles
- E. The byrophyta include
.....algae
.....ferns
.....yeasts
.....mosses

Relations of Biology Questions.

- F. Histology is the study of
.....classification
.....plan breeding
.....minute anatomy
.....history of biology

History of Biology Questions.

- G. Hook discovered the
.....cell
.....heart
.....brain
.....thyroid

General Biology Questions.

- H. The most important part of the cell for heredity is the
.....cell wall
.....food vacuoles
.....nucleus
.....centrosome
- I. In wheat beardlessness is dominant and beardedness is recessive. If a pure beardless and a pure bearded are crossed, the next generation will be
.....3 bearded to 1 beardless
.....all bearded
.....2 bearded to 2 beardless
.....all beardless

GIFT TO TEACHERS COLLEGE.

At the last meeting of the Board of Trustees of Teachers College a gift of \$100,000 made by Mrs. Richard M. Hoe was announced. This gift is for the purpose of endowing a professorship in education, to be known as the "Richard March Hoe Professorship," as a memorial to her husband. Mr. Hoe was a member of the Board of Trustees from 1914 until his death in 1925.

At the same meeting Mr. Valentine E. Macy, a son of Mr. V. Everett Macy, Chairman of the Board of Trustees, was elected a Trustee of Teachers College.

The Trustees granted the request of Professor George A. Coe to be retired from active service on Feb. 1, 1927. Professor Coe is known throughout the country as the author of "What Ails Our Youth."

**"THE SCIENCE WORK OF THE HIGH SCHOOL STUDENT
FROM THE COLLEGE VIEWPOINT."**¹

By R. K. STRONG,

Chemistry Department, Reed College, Portland, Ore.

"The Science Work of the High School Student from the College Viewpoint" sounds a trifle too narrow. There seems no valid reason why a college teacher, who has also taught in high school, should not view the science work of the high school from the point of view of a citizen-at-large.

Let us try to discuss "Aims versus Accomplishments of Science Work in the High School."

Are the aims legitimately: Information, training, elevation? Can there be training—the second of these—without a basis of information—*facts*? Can there be elevation—the last—without a basis of training—*method*? Can there be satisfactory students, in or after high school, or good citizens, without a basis of elevation—*character*?

It seems as if the mere formulation of these three questions necessitates three affirmative answers. *Facts*; by study of them, *Method*; and through proper methods, *Character*.

First, what can one assume as a starting point in the teaching of high school science,—and for that matter, the teaching of college science?

Answer, "Nothing. Only the aims." Beginning with nothing, one may get somewhere in time if the aims are correct. You will please note that this answer does not state that none of the students know anything, it simply says, "Assume nothing!"—not even ability in spelling and multiplying. If this is done the course may be *charted*, and everything that is found to be known by the student is so much gained.

And here may I not be permitted to voice an opinion, strictly as such: The *good* teacher should have an opportunity to exercise his or her individuality in the work, in charting and following out the course, whether physics, or chemistry, or botany, or zoology. This is, I am aware, a more or less unorthodox, even antiquated, view, as the tendency seems to be toward unification and standardization of courses, and of teachers. This may be good enough for teachers, although I

¹Read before the division of Science and Mathematics Oregon State Teachers' Association, December, 1925.

question that, but certainly not for producing *good* teachers, by whom only can science work accomplish the results expected of it.

What inspiration can be obtained by a student who is asked to cover so many pages of a standardized textbook each day or each week? In science, perhaps more than in any line of endeavor, is it not the teacher who largely inspires the worker? What is the reason *you* are teaching the subjects you are? Is it mere chance? Is it to earn a living? Is it because an authority has selected you? Or, is it because you have a passion for the subject, a passion, kindled in all likelihood by some inspiring teacher? If the last, as it should be, "Go thou and do likewise." The more the textbook is used and regarded, the less the value of a teacher, and the fewer the positions. The way to make a place for more science teachers and greater advancement for those teaching science is for those teaching to demonstrate their necessity, and their ability to inspire. Let science teachers, therefore, take the highest pride in their profession, putting enthusiasm into the work, individuality, and doing everything in their power to command respect for science and the *good* teachers of it.

Second, what are the *aims* of science teaching in the high school? As we have said, they are three: Information—facts. Training—methods. Elevation—character. And *not to attempt too much*.

In order to produce the largest number of the best possible citizens, the highest aims should be anchored to possible accomplishments. We must not *overshoot* the target, nor may we, on the other hand, *undershoot*. To quote Professor Grandgent, who pictures with derision a more or less prevailing tendency of the day:

"How fast, Sir, may an eager pilgrim go?
Behold, my limbs are nimble for the chase!"
"No faster than the slowest of the slow:
The lamest, laziest one shall set the pace.
A pilgrimage must never be a race.
Not equal all, but all must equal seem.
Of emulation banish every trace!
All goes to a single gait I deem,

Though none should ever reach the Heights that yonder gleam.
Thou runnest faster than thy fellows can;
Thousands of lads cannot keep step with thee.
For one to know, and other people not
Were sore unjust. Far better none than one."

The *aim* should be to turn out "top-knotchers," but the anchor necessitates good training and opportunity for the many. I dare to say for "many" and not for "all." Nor should we forget that the precocious youth who knows everything in himself and can be told nothing by another is not the most likely to become a "top-notcher." There are elements in such a *character* which operate to his disadvantage in the long run. Most frequently the student of moderate ability, who is industrious, can learn to be observant, and can acquire skill, when touched by the spark of enthusiasm which only a *good* teacher can impart, makes the large success ultimately. A teacher cannot supply the brains to students, but he can show the value and use of them when they are discernible.

Sir Arthur Helps says, "I do not know anything, except it be humility, so valuable in education as accuracy—and accuracy can be taught." And we can, with the proper humility, add, taught nowhere better than in science, where concrete and abstract blend.

As to the information, or *facts*, to be studied.

Is it not most important that the student learn something of the world in which he finds himself?

"Once upon a time" there was a student in first year college chemistry who had had high school chemistry. And in the course of the indoor laboratory work, the teacher chanced to ask her (this is a true story) what chemistry there was to be noted between the laboratory and her home. She said there was none. When asked where she was living, she replied, on Hoyt Street, Portland; and it came out, farther on in the conversation, that she went to and from college by street car. By means of a series of questions, the first of which was, "What do you step on when you get off the street car?", she was able to see that there was chemistry that was not in the laboratory or lecture room. After weeks of diligent effort, enthusiastically performed, she succeeded in preparing a very satisfactory paper on "The Chemistry of Hoyt Street"—the concrete, the grass, the trees, the electric wires, the insulators, the rails, the earth,

the air. Not that she fathomed all the chemistry there, far from it, but she saw that there was chemistry there—and, let us hope, elsewhere; that it is a subject that has contacts with everyday life.

I wonder if the high school is not a better place than college to learn this. By tradition and almost necessity a college course must be quite systematic and disciplinary. There are facts which can be more readily and gainfully obtained in a high school course than in a college course. With this information in hand the college course can be made better than without it, and those who do not go on to college have acquired something of significance in their lives.

I believe the complexity of science should not deter from studying this relation to everyday life: the air we breathe, that blows upon us, that sustains life of plant and animal; its composition and properties; the properties of its individual constituents; its significance in meteorology, navigation, in stopping a railroad train, in windmills; its importance in the burning of substances, whether in the furnace or fireplace or spectacular destructive fires; the effect of its density in flying or mountain climbing, and in submarines and caisson work; the relation to ventilation and the automobile engine—to name a number of topics, which occur quickly and are unarranged. At a glance you see there are fundamental facts involved in each, and that they have important bearings, even to the edge of the unknown for each of us. "Not too much," but as far as you in justice can—and thoroughly.

Water, too, than which there is no more engaging nor important substance for study in the universe! The numerous facts about water need to be known to the botanist, the zoologist, the physicist, the chemist; in the routine and research of science; and, these are of significance to the business man, the traveler, the economist, the social worker, and the householder.

And to cite other topics each for its proper place:—soils, rocks, minerals and ores; the burning process and heat energy; the metric system of weights and measures—now used by all but two most advanced nations in the world; common plants and animals; common machines; materials of construction; clothing; foods. There are understandingly simple and fundamental things of science in all of these, and they are full of fascination for the student when taught by the *good* teacher. Read in this connection, if you will, such books as: Faraday's

Lecture, "The Chemical History of a Candle"; Bragg's Lectures, "The World of Sound"; Fabre's "Mason Wasps"; Fabre's "Wonder Book of Chemistry"; Sharp's "The Spirit of the Hive"; and see, in addition to the discernment of simplicity in complex, information clothed with the art of expression.

Cultivate observation of prevalent phenomena—"Without grist the mill cannot grind." "Begin with what you know" demands knowing something—the philosophy of "I know that I know nothing" is not for science work.

In a drive along the banks of the Willamette River recently, one of the party said seriously, "What makes the water muddy?" One familiar with Oregon weather might be expected to know something about this, but it is doubtful whether this person had ever seen a sample of the river water which had been allowed to stand in a glass vessel, or samples of such river water compared in the wet and dry seasons, much less to have the information that certain rivers in Oregon and Maine contain the smallest percentage of *dissolved* solids of all rivers in the United States.

I know well the antipathy to descriptive science, but what can anyone work on before this "description" is acquired? It is essential for elementary and advanced study; and need not be superficial. Rather a more limited number of topics, a little less up-to-dateness, and more of the real grasp of the topics that are considered. Would it not be better in the study of the heat of fusion of ice to go to considerable pains and extra effort, if necessary, to devise a demonstration using ice and water than to use the cooling curve of naphthalene as an analogy—another true story.

As to training in the *methods* of science.

The generalizations follow in a natural, logical manner, if the foundation of facts is properly laid. "Not too much" again, but rather comprehension of what is taken. It is as foolish to try to teach all of physics or chemistry or botany or zoology in high school as to attempt to do this in the first year college course. Let there be a real, determined aim to cover a portion, one layer, well—too *thin* is to lose *all* too soon.

As important as generalizations, vastly more important, most of us believe, is the *personal contact with nature*, either in the workshop of everyday life or in laboratories devised by man. Here is the greatest gift a good teacher can impart; the training in skill to do the work correctly, and correctly the first time.

Beginners must be shown how to do things, and are entitled to be shown the right way at first. Start the student right with plentiful help, and then let him do as much for himself as his acquired skill *gradually* permits. We have an advantage in laboratory science instruction that is not always used to the full. We are hearing about the grading of classes. It can be automatically and painlessly done in the science laboratory, by allowing more flexibility as to ground covered. It is expecting the impossible to look for each student, with their varying abilities, to work at the same rate. Why not frankly recognize this and arrange for what work can be done satisfactorily by each? To retort that it cannot be done is to evade, unless it has been tried. It works in first year college classes. If we are willing to concede that "The lamest, laziest one shall set the pace" then we submit to the domination of our classes by that lamest, laziest one, and the fault is our own. "Emulation," there must be; competition, if needful; and a recognition that the race is to the swift in school and life.

Of the laboratory aspect of science, Lord Kelvin has this to say: "There is one thing I feel strongly, in respect to investigation in physical and chemical laboratories, it leaves no room for shady, doubtful distinctions between truth, half truth and whole falsehood. In the laboratory everything tested or tried is found true or not."

Aims versus accomplishments! Without aims, no satisfactory accomplishments; with proper aims, discouragements, no doubt, but results that quite outweigh a voyage without a plan.

"Mastery," says Professor Miall, "comes by attending long to a particular thing—by inquiring, by looking hard at things, by handling and doing, by contriving and trying, by forming good habits of work, and especially the habit of distinguishing between the things that signify and those that do not."

There is *method* in this, and the development of *character*, our highest aim.

"To be able to observe details and distinguish resemblances and differences are attributes of every scientific observer."

"The scientific mind," Rowland has said, "is the only mind which appreciates the imperfections of the human reason, and is thus careful to guard against them."

Science study should cultivate a temper of mind which seeks for conclusions but does not jump at them; a mind deliberative, alert, accurate, honest.

FREE AND INEXPENSIVE SCIENCE EQUIPMENT.

BY DUANE ROLLER,

University of Oklahoma, Norman, Okla.

A large amount of free material may be secured from various industrial concerns and educational agencies. It consists mostly of catalogs, pamphlets, charts, exhibits, slides and films and much of it is of considerable value in the teaching of science.

The use of this type of material in the schools is not new. Many teachers already know of the monographs and charts which are being distributed by several manufacturers of physical apparatus. Others are making good use of the slide and exhibit services maintained by various government bureaus and of the exhibits and process cards given to schools by a number of industrial concerns. The use of such material is not an untried experiment. It has been employed successfully in science teaching, and is considered by many to be a valuable addition to the school science equipment.

Teachers have learned in various ways of the existence and sources of free material. Several of the periodicals devoted to the sciences and to science teaching give publicity to such of it as comes to their attention. The advertisements of industrial concerns are read by some teachers for offers of literature or exhibits which might be useful to them in their work. The generality of science teachers, however, are unacquainted with the wealth of useful material which can be obtained for the asking. There are numerous publications and exhibits which are not advertised in the educational and lay periodicals. To learn of them, it is almost necessary to write to many firms and societies at random, asking them to send "anything" they have which is suitable for a given school subject. The concerns affected can pursue one of several courses with respect to such requests. They can search through their publications, often voluminous, for something suitable. This implies that they are in a position to decide what is of value for specific school purposes; moreover, it implies that they are interested in placing their publications in the schools as a part of their advertising program or else as a part of their obligation to society. As another alternative, these concerns can send all of their publications to the schools, a course which is both expensive and wasteful, for experience has shown that only about twenty-five per cent of all industrial publications have any value whatever for school purposes.

It is not difficult to see that indefinite requests for free educational material are likely to prove a source of annoyance to industrial concerns, particularly if the requests are numerous. In fact, in a few isolated cases known to the writer, certain concerns have considered it necessary to adopt the policy of ignoring such requests. Such cases are rare however, for most industrial firms are willing to assist the teacher in any way they can.

Each teacher should keep a record of titles and sources of free material which he finds useful and he should communicate this information to periodicals such as *SCHOOL SCIENCE AND MATHEMATICS* and to his fellows at professional meetings. The writer has collected considerable information of this kind which has been published as a bulletin by the Department of Physics of the University of Oklahoma. This bulletin will be sent free to any science teacher who requests it. It describes about five hundred free pamphlets, exhibits and other materials useful in science teaching and classifies them as suitable for physics, chemistry, the biologic sciences, or general science, as the case may be. Some of the material listed is of value also to teachers of agriculture, physiography, domestic science and manual training.

The useful literature which can be obtained free is usually issued in the form of catalogs, descriptions of manufacturing processes, plants and products, research bulletins and educational monographs. Literature can be obtained which explains in simple language the elementary theory and practise involved in such subjects as the telephone, the gyro-compass, photographic chemistry, lenses and x-rays. Descriptions are available of the process of manufacture of brick, paper, flour, carborundum, typewriters, yeast, adhesive plaster, white lead, cereal products, watch springs, table salt, fountain pens and similar products. Free health bulletins deal with such topics as the relations of temperature and humidity to health, common causes of blindness, school ventilation, care of the eyes, causes and prevention of overweight, first aid, the nature and prevention of the common diseases, dietetics, hygiene and home sanitation. Among the process cards and exhibits given or loaned to schools are those which illustrate with actual specimens the stages in the manufacture of chocolate, steel pens, cereal products, cement, fountain pens, and lead pencils and other which show specimens of various

substances, such as ores, commercial chemicals and different kinds of wood.

Some firms and societies have prepared literature and charts with a specific view to their use in schools. Representative of this kind of material are a series of lectures on electrical apparatus; wall charts showing sectional views of telephones, wheat grains, voltmeters, wattmeters and flour mills; wall charts illustrating such subjects as the periodic system, baking powder ingredients, the anthropometry of school children, chemical stages in the manufacture of photographic film, commercial products of zinc and lead and agricultural products and processes. Other free educational monographs deal with school lighting, experiments in electrical measurements, fire hazards in schools, the history of electric light, of the typewriter and of the sewing machine, the nature of the various scientific and professional vocations, and methods of teaching chemistry, physics, photography, agriculture and various other secondary school subjects.

The greater part of free literature is, of course, in the form of catalogs, such as any industrial firm issues. These catalogs often contain excellent photographs and diagrams and are useful in the study of such devices as boilers, thermostats, pumps, precision balances, irrigating machinery, mechanical stokers, automatic fire alarms, chronometers, refrigerating machinery, and meteorological, optical, electrical and other scientific instruments of precision. Practically all the apparatus and machinery of modern science and industry are described and illustrated in catalogs. Such material is especially useful in schools remote from large urban communities.

Mention should be made of the thousands of lantern slides and films which can be borrowed from Government bureaus, educational societies, and a number of industrial concerns. This visual material covers almost every conceivable subject. Many of the slides furnished by the Government are made in natural colors from carefully selected photographs. Teachers who do not have projection apparatus can obtain from some of the Government bureaus sets of enlarged photographs, sometimes made from the same negatives as the lantern slides. While it is ordinarily necessary to pay transportation charges on this borrowed material, it is possible to arrange circuits with other schools, so that a set of fifty slides, valued at from twenty-five to fifty dollars, can be used for a week at a cost of about one dollar. Considering the cost of slides, it is doubtful whether the science

teacher is justified in buying many slides, when such a great variety of them can be borrowed with so little expense.

The value of some of the material which has been mentioned can hardly be over-estimated. Many of the charts and exhibits are as good as or better than those of a similar nature which can be purchased. The literature generally contains reliable information, often on subjects not discussed in the ordinary elementary textbooks.

The function of science equipment obtained in this way is largely supplementary in nature. It helps to satisfy the demand for a vast and varied assortment of equipment, a demand which is becoming insistent in this day of projects and of general science. The scope of school science has been increased enormously by our modern conceptions of subject-matter, and teachers who are making the most of these new conceptions cannot hope to acquire all the equipment and literature which is needed for their work. At best, the teacher in the average secondary school can hope to purchase only the equipment for which he has continual use. This includes the apparatus which is an integral part of the technique of the various sciences, the best contemporary books, and the classics of scientific literature. For this kind of material there is no satisfactory substitute. It is the nucleus of the science equipment.

Free material, on the other hand, is supplementary equipment, in that it helps to supply the demands for material which is not used regularly, or which is not a part of the traditional science equipment. The specific nature of these demands cannot always be anticipated, and when they arise, there should be a ready and inexpensive way of satisfying them. Often the demand is so unusual that there may never again be a need for the same apparatus or literature, in which case it may be unwise to purchase it from a possibly meager science budget.

Let us illustrate the use of free material by a hypothetical case, in which some pupils enrolled in general science have expressed the desire to know something about the manufacture of steel pens. The average school library could hardly be expected to reveal anything more than some encyclopedic information on this subject, while the school science equipment would yield nothing at all in the way of illustrative materials. All of this is probably as it should be, for it would be a foolish contention, even as an ideal, that a secondary school should possess everything. Nevertheless our assumed situation has created a de-

mand for literature and if possible exhibits dealing with steel pens. This material might possibly be purchased. Extended treatises on the manufacture of steel pens probably are extant. But who cares to read them? Not even the average student interested in steel pens has use for an extended treatise on the subject. It is in a case of this kind that free industrial material is especially valuable; in this situation it has no practical substitute. On the subject of steel pens, there are available several free booklets which treat of their history and manufacture in non-technical language, and at least two free process cards exhibiting actual steel pens in all the major stages of completion. If our project happens to lead on into the subject of fountain pens, there is available free literature on their history and manufacture, many photographs of the interiors of plants where they are made and a twenty-piece exhibit containing raw materials and the parts of such pens.

There are other sources of inexpensive material besides the industrial concerns and educational agencies. Science collections and museums composed of locally obtained materials are often of value and should be encouraged. Teachers of physical science should make more use of old magnetos, parts of bicycles, gear wheels, telephones, coils, spark plugs, clocks, electric cells, and countless other articles which can be obtained in any town for little or nothing. The biology teachers have long used local fauna and flora to advantage and teachers of physical science have much to learn from them in this regard. Home-made apparatus also deserves more consideration, although it must be admitted that it has not always justified the claims which its exponents make for it. There are many teachers who regard home-made apparatus as impractical. This may be due partly to the fact that too much has been expected of it. Elaborate apparatus can seldom be made by amateurs, and attempts to do so generally result in losses of time and money, two resources not possessed in abundance by teachers. Experience has shown, however, that very simple apparatus can be constructed successfully and cheaply and that there are a great many pieces of simple home-made apparatus which are useful in the classroom and laboratory.

There are many who believe that a dearth of supplementary literature and other equipment is a serious obstacle to successful project teaching. They contend that an unreasonably large and varied equipment is demanded for this method and that this

constitutes a serious objection to its use. Whether or not this contention is sound, there is no doubt but that an abundance of equipment is desirable and that every teacher who has faith in the educative value of projects will seek every means to enlarge his science equipment. Those who desire to use the project method and those who teach in poorly equipped schools should investigate every possible source of free and inexpensive science materials.

EARTHQUAKE IN MONTANA.

REPORT ISSUED BY DEPARTMENT OF INTERIOR.

The earthquake of June 27, 1925, in Montana, which caused considerable damage within an area of 600 square miles or more, is described in a report recently issued by the Department of the Interior as Professional Paper 147-B of the Geological Survey. The report was written by J. T. Pardee, a geologist of the Survey.

The earthquake was severe, but, owing to the hour at which it occurred (6:21 p. m.) and to other fortunate circumstances, no lives were lost and no fires broke out. The shock originated at a point near Lombard, Broadwater County. Within the area of greatest disturbance brick buildings suffered severely, rocks fell from cliffs, cracks opened in the ground, and the inhabitants experienced the usual symptoms of illness and emotions of alarm.

The main shock was preceded by two light foreshocks and followed by a great many aftershocks, one of which, occurring about three-quarters of an hour later, was almost as severe as the main shock.

The point of origin, known as the epicenter, is in Clarkston Valley, a lowland surrounded by mountains of closely folded rocks of Mesozoic and earlier age and floored with Tertiary "lake beds" and recent alluvium. The surface features of the region indicate that Clarkston Valley is not like most valleys due to erosion by a stream, but is a depression in the rocks caused by a break or fault in the rock strata. Presumably the origin of the earthquake was movement on this fault at a considerable depth below the surface.

POORLY CONSTRUCTED BUILDINGS WRECKED.

The greatest damage was shown by the school buildings at Manhattan and Logan and a church and a school at Three Forks, all of which were built of brick. The church was almost a complete wreck. The schoolhouses, though seriously damaged, were not beyond repair. From even a casual inspection of the towns mentioned and the surrounding region it is apparent that all well-constructed buildings of whatever type escaped with little damage. Buildings faced or veneered with brick laid without being tied or bonded to the inner walls suffered the most. Some walls were wrecked owing to the use of poor mortar, which allowed the bricks to separate from one another.

NARROW ESCAPE OF RAILROAD TRAIN.

At the west portal of the Chicago, Milwaukee & St. Paul Railway's tunnel No. 8, near Deer Park, the earthquake caused a rock slide, estimated at 40,000 cubic yards, that not only blocked the track but dammed Sixteenmile Creek, producing a lake. Two sections of a west-bound passenger train had only a few minutes before passed the portal of the

tunnel. They came to a stop while huge rocks were falling on the tracks in front of them and behind them, and their escape without a scratch seems little short of miraculous.

EMOTIONS AND SENSATIONS OF INHABITANTS.

The earthquake was violent enough to alarm the inhabitants generally throughout an area having a radius of 75 miles from Lombard. At some places many persons became wildly excited or hysterical, and the alarm caused by the main shock was renewed and increased by several of the aftershocks. Numerous persons were partly or completely thrown down and in falling caught at the nearest object for support. A lady thus thrown in the street at Three Forks found herself clasping the knees of a strange man. As soon as persons were able to regain their feet or make progress despite the earth movements they lost no time in getting out of doors. In their excitement some persons picked up articles of no value. At Butte a woman is said to have laid down her baby and picked up a cat. Within a large area nearly everyone experienced more or less dizziness or nausea, and many felt a nervousness difficult to overcome for days or weeks afterward.

MINES WITHSTOOD SHOCKS.

Contrary to a rather widespread apprehension, the workings of mines were not damaged by the earthquake, and in fact the shock was not generally noticed by the miners who were underground at the time. In view of the fact that mine workings are generally so constructed as to withstand the jars from blasting, it is not surprising that they resisted damage by the less violent vibrations of this earthquake. Furthermore, as earthquake vibrations are less destructive in solid rock than in loose materials, they would be less noticeable under ground than at the surface.

CHANGES CAUSED IN SPRINGS AND WELLS.

The flow of many springs within a radius of 50 miles from the epicenter was increased or diminished, and some were made turbid for a short time. Several wells went dry, and others became muddy. An oil well near Cody, Wyo., that had been unproductive for several years "blew" considerable gas and oil for a few days. The well started flowing about noon of the day after the earthquake, and by the middle of the afternoon the flow had reached such proportions that the fire hazard appeared too great for trains to pass a hundred yards away.

MOTION DESCRIBED AS VIOLENT BUMPING AND ROCKING.

Observers near the epicenter described the earthquake motion as a violent bumping and rocking. Elsewhere practically all described it as a rocking motion. Visible ground waves, much like the swells in the wake of a steamboat, were reported by many persons. Similar waves were indicated by the behavior of buildings, fences, telegraph poles, etc., which were observed to lean to one side and then to the other, describing arcs of as much as 30° . Standing automobiles, including a heavy tractor, were seen to dance a comical sort of jig, rising first on one side then on the other.

OVER 300,000 SQUARE MILES AFFECTED.

The total area throughout which the shock was sensible to persons is about 310,000 square miles, comprising Montana and the adjacent parts of Washington, Idaho, Wyoming, and Canada. The disturbed area is therefore of about the same order of magnitude as that of earthquakes of the first rank. The intensity was apparently somewhat less than that of the California earthquake of 1906, and owing to the lack of populous cities near the epicenter, the damage was comparatively insignificant.

TEXTBOOK SOLUTIONS OF ALGEBRAIC PROBLEMS.

BY PAUL LIGDA,

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Some modern textbooks in elementary algebra inform pupils that: "The purpose of this study is to enable you to solve problems that cannot be solved by arithmetic methods." They then present convincing illustrations of the hypothetical difficulties encountered by ignoramuses blundering through unwieldy arithmetic solutions, contrasting the latter with the clear, concise, logical, and systematic algebraic method.

But many algebra teachers know that sometimes the ignoramus gets the best of the argument. Incidents of the following kind frequently happen in the best conducted classes: The textbook gives an elaborate solution and explanation of some "type" problem. During the classroom discussion, just when the interest is at a high pitch, a piping voice is heard: "Teacher! I see an easier way of solving this problem." The teacher, trusting to the fact that generations of eminent mathematicians have refined the method of solution presented in the text, indulgently allows Johnny to show his method, cannily expecting to obtain some valuable material for a lecture on the presumption of youth.

But the unexpected happens. Johnny writes two or three short sentences on the blackboard, and the problem that required a whole page of complicated symbolic manipulation is solved by means of a simple idea and a couple of short multiplications or divisions, without the slightest need of an x or a y . The class titters and all the impromptu explanations of the flustered teacher fall on deaf ears. The class has formed the impression that arithmetic plus common sense will solve problems by means of methods easier than algebraic methods. Unless the teacher is prepared to meet them, a few occurrences of this type will demoralize a class by destroying confidence in the teacher as well as in the subject.

The purpose of this article is to present a few troublesome problems of this kind, together with the actual solutions brought in by the writer's pupils.

Problem 1. A train leaves a station and travels at the rate of 40 miles an hour. Two hours later a second train leaves the same station and travels in the same direction at the rate of 55 miles an hour. When will the second train overtake the first?

Hotz's test of problem solving ability contains this problem which may also be found under various disguises in all textbooks. The December, 1924, number of *SCHOOL SCIENCE AND MATHEMATICS* contains an article by Mr. Hughes who informs us that only seven out of twenty-six University seniors and graduate students, having an average of six years training in mathematics, managed to solve this problem. The natural conclusion is that it must be difficult, at least if algebraic methods are used. The following solution is given in a textbook:

Let x = the number of hours that the second train travels.

Then $x + 2$ = the number of hours that the first train travels.

$55x$ = the distance traveled by the second train and $40(x + 2)$ = the distance traveled by the first train.

By the conditions of the problem

$$55x = 40(x + 2), \text{ etc.}$$

But Johnny offers the following solution: The first train travels 80 miles before the second train starts. The latter reduces this lead by 15 miles every hour. Therefore it will take $80/15$ hours to overtake the first.

There is not anything to criticize about this solution, for it can be applied to all problems of the "overtaking" type, found by the dozen in every textbook. The fact that aeroplanes, automobiles, pedestrians, bicycle riders, or any combinations of these, are involved, and that the numerals are different, will not deceive Johnny very long.

As an aside to our discussion: Should it really require six years of mathematical training to be able to solve this problem?

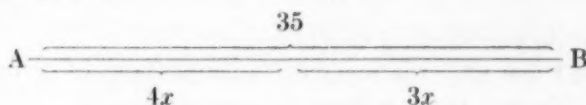
But our teacher knows that even a slight change in the conditions of a problem alters the method of solution, so she selects the following:

Problem 2. Two men, A and B, start from places 35 miles apart and walk toward each other at the rate of 4 miles and 3 miles an hour respectively. How many hours will it be before they meet?

The solution that she found in the textbook was:

Numbers dealt with	Symbols
Number of hours A travels	$= x$
Number of hours B travels	$= x$
Number of miles A travels	$= 4x$
Number of miles B travels	$= 3x$
Total number of miles traveled by A and B	$= 35$

The formation of an equation is greatly facilitated by drawing a diagram; thus:



"Now, Johnny! Can you improve this?"

"Sure! They approach each other at the rate of 7 miles an hour. In $35/7$ hours they meet."

And a perfectly good group of problems that immediately follows the illustrative problem is spoiled so far as this class is concerned, for the whole class proceeds to solve them mentally, unless forcibly restrained by the harassed teacher.

This problem is sometimes made more complicated by having A start a few hours before B. But Johnny merely subtracts the distance traveled by A from 35 and then proceeds as above.

One teacher was determined to prove that some problems could not be solved by arithmetic methods. She searched the second half of the text-book and copied the following on the blackboard:

Problem 3. Two motorists start at the same time to ride from A to B, 240 miles distant. One travels 10 miles an hour more than the other. The faster motorist reaches B and at once starts back, meeting the slower one at C, 192 miles from A. Find the rate of each.

Solution. The problem states that the two travel at different rates, that they travel different distances, but that the time is the same for each. Hence the equation must be formed by expressing the time t , or d/r for each and equating the two expressions for t .

The two men together cover twice the distance from A to B or 480 miles. As the slower one travels 192 miles, the faster travels $480 - 192$ or 288 miles. If x = the rate of the slower motorist in miles per hour, we have:

	d in miles	r in miles per hour	$d/r = t$ in hours
Slower motorist	192	x	$192/x$
Faster motorist	$480 - 192 = 288$	$x + 10$	288
			$x + 10$

Hence
$$\frac{192}{x} = \frac{288}{x+10}, \text{ etc.}$$

"What do you think of this, Johnny?"

"I don't see why the equation *must* be formed in the way shown. We may make it from the rate statement:

"Rate of one = rate of the other + 10

"If t = time in hours,

$$\frac{288}{t} = \frac{192}{t} + 10$$

" $288 = 192 + 10t$, then find the rate.

"This shows that we can figure this way:

"The faster machine travels 96 miles more than the slower.

"Since it travels 10 miles an hour faster, the time required is $96/10$. Then the rate is found at once. You don't need that tabulation and fractional equation. It looks too much like shooting at birds with a cannon."

"There is a problem on the next page of the textbook which is even simpler.

"Problem 4. A man travels at a uniform rate from A to B, 150 miles distant. He travels the first 90 miles without stopping. The rest of the journey, including a delay of three hours, takes the same time as the first part. Find his speed.

"Hints. By reading the problem we discover that the distances covered in the first and second portions of the journey are different, that the time of travel is not the same for each, but that the rate throughout is the same. Hence one should find the two expressions for the rate r , or d/t , and set them equal to each other.

"If we let x = the time in hours, we would obtain the equation:

$$\frac{150}{x+3} = \frac{60}{x}, \text{ then find the rate.}$$

"This is a roundabout way. Why find the time, then the rate if the procedure is not thereby simplified? Why not find the rate directly from the time equation:

"Time for 90 miles = time for 60 miles + 3 hours

$$\frac{90}{r} = \frac{60}{r} + 3, \text{ etc.}$$

"But the easiest way is through the use of another condition:

"If he had traveled during the 3 hours that he was delayed, he

would have covered 30 miles. Hence his rate is $30/3$ hours."

The teacher was getting worried. That evening she looked over the textbook again. The next day she assigned the following problem which was not solved in the book, but which appeared rather difficult.

Problem 5. A train runs 280 miles. On the return trip it increases its rate by five miles an hour and makes the run in an hour less time. Find its rate going and coming.

The next day no one in class had a solution, not even Johnny. When the teacher sarcastically asked why he had failed he replied that he had been unable to reason it out. But Jimmy, the dumb bell of the class, came to his rescue:

"I asked my big brother to help me to solve this problem, but he could not solve it by simple equations. So he took it to Mr. Ligda, a neighbor of ours, who wrote a book in which problems are analyzed. Mr. Ligda said that this problem, together with three other problems on the next page, can be solved only by means of quadratic equations. But these equations are studied in the last chapter of the book. Let us see how you solve it by means of simple equations."

Horrors! Jimmy was right! The author must have selected some numbers, made up the problems, and not solved them himself before placing them in that group. Several textbooks examined by the writer contain such misplaced problems, in spite of the fact that in one preface it is stated that: "The course of study was mimeographed and tried out in a large number of classes, several thousand children and a large number of teachers participating in the experiment."

The teacher wanted to save something from the wreck. "You are right. These problems do require quadratic equations. These must be learned in order to solve problems otherwise impossible of solution. Let me show you a solution."

Problem 6. The side of a square is 10 inches. By how much must each side of the square be increased in order that the area may be multiplied by 9?

Solution. Let x = the amount to be added to the side.

Then $(10+x)^2$ = the area of the square after the increase.

But this area = 900

Therefore $100 + 20x + x^2 = 900$

Simplifying $x^2 + 20x + 800 = 0$

Then the teacher completed the solution by means of the formula.

The children looked expectantly at their champion. He did not disappoint them. Here is his contribution:

"The area of the original square is 100; of the increased square, 900. Extracting the square root of 900 gives 30 for the side of the increased square. Therefore add 20 inches."

"Fine," said the teacher, "you found the flaw in that problem. Let us see if you will be as lucky with this one:"

Problem 7. Find the side of a square whose diagonal is 3 in. longer than the side.

Here is the book solution:

Letting x represent the number of inches in one side of the square, we have $x^2 + x^2 = (x+3)^2$
whence $x^2 - 6x = 9$

Adding 9, the square of half the coefficient of x , to each side, we have

$$x^2 - 6x + 9 = 18$$

Taking the square root of both sides, we have

$$x - 3 = \pm \sqrt{18};$$

whence

$$x = 3 \pm \sqrt{18} \text{ etc.}$$

"Well," said Johnny, "you did some things that I did not understand very clearly, but I noticed that you took the square root of each side of the equation. I never thought of doing that before, for the book does not give any axiom justifying this step. Now that I know it I can give you a simpler solution. Starting from the first equation

$$2x^2 = (x+3)^2.$$

"Extracting the square root of each side

$$\pm x\sqrt{2} = \pm (x+3)$$

"Taking the positive values, transposing x , and factoring,

$$x(\sqrt{2}-1) = 3$$

whence

$$x = 3/(\sqrt{2}-1)$$

"This is simpler than the book solution and does not require any knowledge of quadratic equations."

"You are right, Johnny, I should have selected something that could be solved in one way only. Let us examine this problem:

"Problem 8. The length of a rectangle is 2 ft. more than its width, and the area is 143 square ft. What are its dimensions?

"Let the length = L
and the width = W

"Then $L = W + 2$, and $LW = 143$

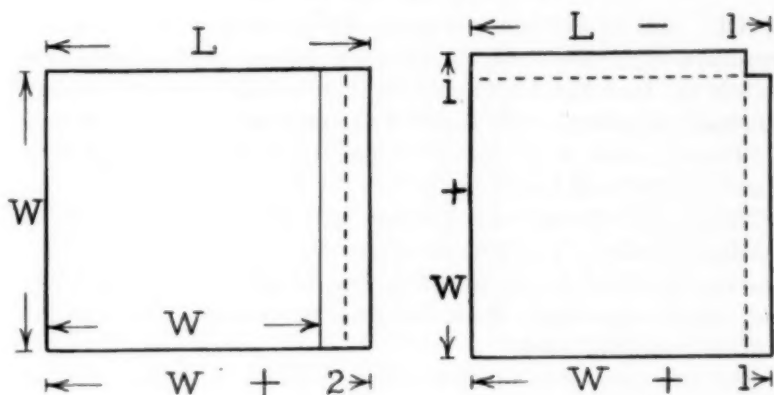
"Substituting the value of L into the second equation

$$W(W+2) = 143$$

"Solving this quadratic equation, we obtain $W = 11$, or $W = -13$.

"But since the width of a rectangle cannot be a negative quantity, we take the first value."

"I do not quite understand this two root business," said Johnny. "How can an unknown have two different values? They may satisfy the equation, but they do not satisfy me. Besides, how does it happen that the negative value, -13 , also happens to be the value of the length? We seem to obtain the values of the length and of the width at once, the only trouble being that the former has the wrong sign, and we were not solving for it at all. Wait! I have an idea!"



"Draw the rectangle. Lay off the width on the length. The rectangle $2W$ is left. Divide the rectangle $2W$ into two equal parts $1 \times W$ and place one of them horizontally on top. We have now an incomplete square having an area of 143 sq. ft. The little square needed to complete the large square has an area of 1×1 square ft. Now we have a complete square having an area of 144 sq. ft., and hence a side of 12 ft. But this side may be called either $W+1$, or $L-1$.

"Therefore $W+1 = 12$
and $L-1 = 12$

"This way I get both unknowns at once and there are not any double roots."

"In practice I would solve as follows:

"Given the equations

$$L = W + 2, \text{ and } LW = 143.$$

"Subtract one half of the constant term from each side of the first equation

$$L - 1 = W + 1 \quad (1)$$

"Square this half of the constant term and add it to the constant term of the second equation. Then write the terms of (1) as factors on the left side of the final equation and the completed square on the right side

$$\begin{aligned} (L - 1)(W + 1) &= 144 \\ &= 12 \times 12 \text{ or } (-12)(-12) \end{aligned}$$

"Now the two factors on the left side are equal, since they both stand for the length of the side of the square. This is also shown by (1). Therefore each of these equal factors is respectively equal to one of the equal factors on the right side. That is

$$L - 1 = \pm 12, \text{ and } W + 1 = \pm 12."$$

"Oh," said Susie, "you are using the Ligda method of solving quadratic equations. My brother was in one of his classes and he told me that Mr. Ligda showed them a fourth way of solving quadratic equations. He called it the method of equal factors."

"Does it work in all cases," asked the teacher, "and does it stand on a proved basis?"

"Yes," said Susie, "my brother said that it can be proved mathematically. You always obtain the values of the two unknowns involved in the problem, and it always requires fewer and simpler operations than the usual procedure. This method will be published soon."

The teacher had read that ability to solve a certain class of problems does not necessarily mean ability to solve another class of problems, when the latter deal with different quantities. So she dropped uniform motion and area problems and selected the following "work" problem:

Problem 9. If Sam can do a certain job in 2 days, and Jim can do the same job in 3 days, how long will it take both working together to do the job?

The book gave the following solution:

- | | |
|---|---------|
| (1) number of days it takes Sam alone | = 2 |
| (2) number of days it takes Jim alone | = 3 |
| (3) number of days it takes both together | = x |
| (4) part Sam does in one day | = $1/2$ |
| (5) part Jim does in one day | = $1/3$ |
| (6) part both together do in one day | = $1/x$ |

Relation of equality among numbers

Sum of (4) and (5) = (6).

She knew from previous experience that this was a difficult problem to explain. She had also read that, out of 250 high school graduates tested for their problem solving ability, only six had given the correct answer. So, after explaining the problem thoroughly, she complacently asked if anyone had a better method of solution.

Two hands went up. Susie was given the first chance.

In one day Sam does one-half of the work.

In one day Jim does one-third of the work.

In one day Sam and Jim together do five-sixths of the work.

Since five-sixths of the work is done in five-fifths of one day, one-fifth of a day is required to do one-sixth of the work, and six-fifths of a day will be required to do the whole job.

"Aw," said Johnny, "This is too complicated for me. This is heavy thinking. Adding fractions mentally is not in my line. The only good thing in your solution is the phrase 'of the work.' It would improve the book solution if some symbol such as W were used for *the work*. We would have

part Sam does in one day = $W/2$, etc.

"To have $1/2$ stand for 'one-half of the work' is carrying symbolism too far. Suppose that the work had been sawing 100 sticks of wood. Then Sam would have sawed $100/2$, etc.

"However there is a simpler way of solving the problem.

"Multiply 2 by 3. You get 6 days. In six days Sam can do 3 jobs, and Jim can do 2 jobs. Together they can do 5 jobs in 6 days. To do one job would require $6/5$ days.

"Let me show you how I can work the rest of the problems on the page by my method." And he did solve them verbally in a few minutes, thereby spoiling another long list of problems. Before the next day every pupil in the class knew how to solve these problems—by Johnny's method. But only a few of the teacher's-pet kind had learned the book method. And they did not learn it any too well, for at the end of the term they had forgotten it, while Johnny's disciples still could remember his solution.

The situation was getting beyond the teacher's control. She took her troubles to the head of the Department of Mathematics, and a meeting of the teachers was called to examine the matter. The result of the discussion was the selection of problems 10

and 11. These were considered impossible of solution by reasoning methods. Only four of the 26 college students mentioned above had been able to solve No. 10 and these four had had 9, 8, 7 1/2, and 6 years of mathematical training respectively.

Problem 10. A merchant has two kinds of tea, one costing 50 cents and the other 65 cents a pound. How many pounds of each must be mixed together to produce a mixture of 20 pounds that shall sell for 60 cents a pound?

The textbook explained the problem as follows:

Here the number of pounds of 50 cent tea = x and the number of pounds of 65 cent tea = $20 - x$.

The given information may be tabulated as follows:

	Number of pound	Price per pound	total cost
First variety	x	50	$50x$
Second	$20 - x$	65	$65(20 - x)$
Final	20	60	20×60

The equation is based on the fact that the sum of the costs of the two varieties must equal the cost of the final mixture. Finish the problem.

The teacher was dominating the situation at last. She had prepared a little speech:

"Now, children! So far Johnny has been able to solve problems because they were easy. But when you come to real life problems, involving complex relationships, you will find that system and order are essential. The untrained person simply cannot solve this problem. Johnny! You have been scribbling instead of listening. Give me that piece of paper at once!"

This is what she read:

The price of the tea must be reduced one-third of the difference between 65 and 50 for the 65 cent tea, and raised two-thirds of the same difference for the 50 cent tea. Therefore we must use twice as much 65 cent tea as 50 cent tea. Two-thirds of the 20 pound must be 65 cent tea.

The harm was done! The teacher perceived too late that the author should not have used rounded numbers. If the respective costs had been 49, 66, and 59 cents a pound respectively, Johnny would not have been able to extricate himself from the complicated fractions. It is not very difficult to think in terms of thirds, but very few people can think in terms of seventeenths.

After she had recovered from the shock she directed the

attention of the class to the other mixture problem, guaranteed fool-solution proof. Mixture problems are considered by some authorities to be the most difficult problems in elementary courses.

Problem 11. A mixture contains 3 gallons of alcohol and 5 gallons of water. How many gallons of water must be added to make a mixture that is $\frac{3}{4}$ water?

Solution. In the final mixture:

$$\frac{\text{water}}{\text{water} + \text{alcohol}} = \frac{3}{4}$$

Let x = gallons of water to be added.

Then $5 + x$ = gallons of water in final mixture
and $8 + x$ = total gallons of final mixture.

But

$$\frac{5 + x}{8 + x} = \frac{3}{4}$$

$$20 + 4x = 24 + 3x, \text{ etc.}$$

(Followed by a few problems of the same type.)

When the teacher turned around at the end of the explanation and looked at Johnny, the confident smile left her face, and her heart sank. He looked bored. As his hand was the only one that went up she had to let him spoil another recitation.

"What is the use of all this figuring? Three gallons of alcohol become one quarter of the final mixture, that is of 12 gallons. The original mixture was 8 gallons. Therefore add 4 gallons.

"Do you want me to solve the rest of the problems in my head? They are just as easy."

"No," said the teacher, "try this one out of another book:

"Problem 12. How much water must be added to 20 gallons of milk testing $5\frac{1}{4}\%$ butter fat to make it test 4% butter fat?

"Here is the book solution:

"Let x = the number of gallons of water added

"Then $x + 20$ = the number of gallons of diluted milk

and $\frac{5\frac{1}{4} \times 20}{100}$ = the amount of butter fat in the undiluted milk

and $\frac{4}{100}(x + 20)$ = the amount of butter fat in the diluted milk

"But the amount of butter fat is not changed when the water is added. Therefore

$$\frac{5\frac{1}{4}}{100} \times 20 = \frac{4}{100} (x + 20), \text{ etc.}"$$

"Fine," said Johnny, "but why not tell us from the beginning

that the essential relationship lies in the fact that the amount of butter fat remains unchanged; that we should express that amount in two different ways, and compare these ways? Why not let us see the plan of action and the reason why we must express some quantities in terms of a certain selected one? Why does not some author explain the reason *why* he does certain things in a certain way instead of merely showing us *how* he does them? Now that I can see the plan of action I can solve as follows:

$$\text{Butter fat} = \frac{21/4}{5} = \frac{21}{20} \text{ gal.}$$

"This remains unchanged and becomes 4% of what? 4% is $1/25$, so I multiply $21/20$ by 25, obtaining $26 \frac{1}{4}$ gal. for the final mixture. The original mixture was 20 gal., so we must add $6 \frac{1}{4}$ gal. of water. Next!"

The school was located near a famous university. The teacher took her troubles to the great authorities on educational matters, teaching and researching therein. After considerable pondering it was decided that traditional methods of solution must be saved at all costs, for otherwise the authorities would have to scrap a lot of perfectly plausible-sounding lectures which were giving entire satisfaction to everybody except children. Johnny must be squelched! Problems 13 and 14 were selected for the fell purpose, after due consideration of the psychological, pedagogical, and mathematical principles involved.

Problem 13 was taken from a famous old algebra textbook. Its author considered it so difficult that he gave the complete solution reproduced here. Problem 14 was selected from an old copy of SCHOOL SCIENCE AND MATHEMATICS. The complex solution was followed by the names of two successful solvers, both Ph.D.'s, while seven unnamed but presumably more or less distinguished luminaries had sent incorrect answers. Johnny's finish was in sight!

Problem 13. A train, after traveling an hour from A toward B, meets with an accident which detains it half an hour; after which it proceeds at four-fifths of its usual rate, and arrives an hour and a quarter late. If the accident had happened thirty miles farther on the train would have been only one hour late. Find the usual rate of the train.

Let y = the number of miles from A to B;
and $5x$ = the number of miles the train travels per hour.

Then $4x$ = the rate of the train after the accident.

Then $y - 5x$ = the number of miles the train has to go after the accident.

Hence

$$\frac{y - 5x}{5x} = \text{the number of hours required usually;}$$

and $\frac{y - 5x}{4x} = \text{the number of hours actually required.}$

$$\text{Therefore } \frac{y - 5x}{4x} - \frac{y - 5x}{5x} = \text{the loss of running time in hours.}$$

But since the train was detained a half hour and arrived one and a quarter hours late, the *running time* was three quarters of an hour more than usual.

That is $3/4$ = loss in hours of running time.

Therefore

$$\frac{y - 5x}{4x} - \frac{y - 5x}{5x} = \frac{3}{4} \quad (1)$$

If the accident had happened thirty miles farther on, the remainder of the journey would have been $y - (5x + 30)$ miles, and the loss in running time would have been half an hour.

Therefore

$$\frac{y - (5x + 30)}{4x} - \frac{y - (5x + 30)}{5x} = \frac{1}{2} \quad (2)$$

From the solution of (1) and (2), $x = 6$ and $5x = 30$.

"This, children," said the teacher, "is an example of work done by great mathematicians when they deal with very complicated problems. Only highly trained minds can plan such solutions and organize details in such masterly ways. But maybe Johnny has a better method."

Johnny was awe-struck. He gazed mournfully at the solution and said: "I can never hope to create such a solution. It certainly is some monument! All I can do is to obtain the same result in my own clumsy way."

The difference in time between running 30 miles at schedule rate and at four-fifths schedule rate is one quarter of an hour.

Let x = the scheduled rate.

The time of running at schedule rate is $30/x$.

The time of running at $4/5$ of schedule rate = $30/(4/5x)$ or $150/x$, and the equation would be

$$\frac{150}{4x} - \frac{30}{x} = \frac{1}{4}$$

Multiply by $4x$

$$150 - 120 = x, \text{ or } x = 30$$

The exasperated teacher wrote her last problem on the black-board:

Problem 14. Two men start from opposite shores of a lake to row directly across. Their rates of rowing are uniform, but not the same. They meet 720 rods from the left hand shore, then each rows to the starting point of the other, rests five minutes, and rows back again. This time they meet 440 rods from the right hand shore. Find the distance across the lake.

"Now you solve this, Johnny, or I will keep you after school every day for the rest of the term until you do solve it."

Poor little frightened Johnny went up to the board and wrote:

1. The sum of the distances that the men row is three times the distance across. (Each man rows across once; then they meet.)

2. The first man rowed 720 rods of the first crossing.

3. Therefore he rowed 720 rods of each of the three hypothetical crossings, or 720×3 rods. But he lacked 440 rods of rowing twice across. If we let $x =$ the distance across,

$$2x - 440 = 720 \times 3, \text{ or } x = 1720 \text{ rods.}$$

"Is this all right, teacher?"

But the teacher was tendering her resignation to the principal and suggesting that Johnny be appointed on her job.

Discussion. Many textbook writers are clearly guilty of carelessness, and this carelessness is sure to cause trouble in classes where children are allowed to think and express themselves freely. A policy of repression may be adopted, but this will not prevent children from discussing the short cuts outside of the classroom.

Some teachers might avoid this trouble by confining themselves to the teaching of equations. But this is directly opposed to the recommendation of the National Committee:

"Continued emphasis throughout the course must be placed on the development of ability to grasp and utilize ideas, processes, and principles in the *solution of concrete problems* rather than on the acquisition of mere *facility or skill in manipulation*."

The College Entrance Examination Board in its Document 107, published May, 1923, states that ". . . The examinations are expected to be more searching with respect to the parts of algebra that will be used by the pupil in his later work, and

particularly with respect to his ability to solve *applied problems*, to handle formulas, to interpret graphs, and to solve the type of equations which he will subsequently need to use."

The problems examined in this paper were analyzed by the writer's method* and found possible of solution by two or more different methods. They were then assigned as home work with the comment that they could be solved by means of short cuts. The pupils then paid special attention to them, and competed strenuously for the honor of discovering original solutions. Sometimes the greater part of the class brought in a "Johnny solution" besides the regular and obvious analysis and solution. But the writer took special care to impress upon his pupils the facts that special solutions are not always possible, only good for a small group, usually best found after the problem is solved and the conditions thoroughly understood, and that finally the general method, while more cumbersome at times, is usually safer. But how many textbooks present a workable general method of attack?

*Described in "The Teaching of Elementary Algebra," Houghton Mifflin Company, 1925, Chapters VII and VIII.

THE MENACE OF CO.

Gas attacks, colorless, odorless, deadly, occurring in these days of peace and industry are worrying those who care for the health of the nation.

CO, the chemical symbol for deadly carbon monoxide gas, is taking on a new significance, allied to the conventional skull and crossbones.

Carbon monoxide, the product of incomplete combustion, occurs in most dangerous concentration in garages and service stations, around blast furnaces, near gas fired appliances and wherever gas is burned or internal combustion engines are run. Dr. May R. Mayers of the Bureau of Industrial Hygiene of the New York State Department of Labor reported to the American Public Health Association that over three-fourths of the public garages inspected in New York City showed the presence of some carbon monoxide in their air, while over half of them had concentrations of over one-tenth of one per cent, the danger limit. Nearly three-fourths of the workers gave definite evidence of CO in the blood while some showed symptoms of being poisoned. Steam laundry workers at gas heated ironing machines were found to be affected and there is hardly any industrial activity in which carbon monoxide is not encountered in some concentration.

Lead poisoning, long an outstanding industrial menace, is now said to be second to the carbon monoxide danger. This gas is peculiarly insidious in its action since it may prove suddenly fatal even in minute concentrations without necessarily giving warning of its presence to those exposed. Dizziness, headaches, drowsiness, smarting of the eyes characterize its early symptoms but blindness, paralysis, and even insanity may follow exposure to the gas. A program of investigation, to be followed by attempts at education and control, is planned for New York and elsewhere.—*Science Service*.

ONE INFLUENCE OF OUT-OF-SCHOOL ACTIVITIES IN DETERMINING THE HIGH SCHOOL PHYSICS CURRICULUM.

By M. E. HERRIOTT,

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Those of us who are in the field of education, both as practical and as theoretical school men and women, are constantly giving the major portion of our attention to one particular phase or another of our work. As the psychologist would put it, some one aspect occupies the focus of attention and the other phases are peripheral. As we think back only a few years, we see motivation, problem-project, and testing each taking the foreground in turn. And I believe that I see the method or technique aspect of teaching looming before us as the centre of attention only a few years hence. But just now, we are in the throes, as it were, of curriculum construction and course of study writing.

It was ten years ago that Parker stated the four fundamental principles which have been quite generally accepted as the guiding principles in the selecting and arrangement of subject matter. We are all familiar with them so that a mere mention of each will suffice. First, subject matter should be selected by the criterion of social need. Second, it should be selected on the basis of relative values. Third, subject matter should be organized in large units treated intensively. And fourth, it should be organized in terms of the learner.

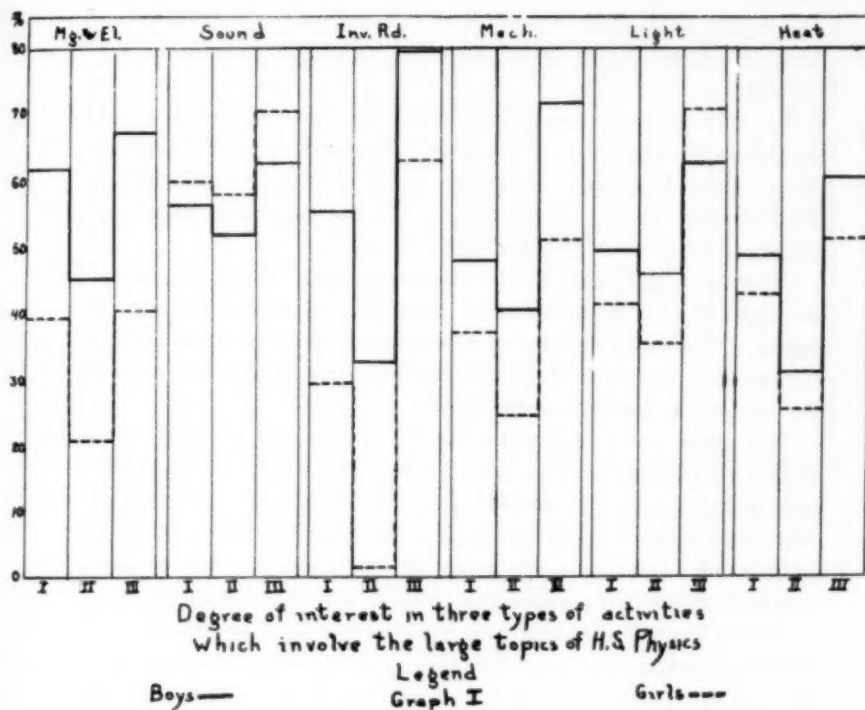
In what I am about to present to you, I am applying, chiefly, the principle of social need to the high-school physics curriculum, insofar as the data collected will permit.

The space allowed me does not permit of my going into great detail as to the source and validity of the original data. I can only ask that you accept them as valid for the purposes of this paper, although I shall briefly sketch what was done.

My purpose at the time of the study was to find out the extent to which the principles and elements of high school physics enter into the everyday lives of ordinary people. So I presented a list of 576 activities to a group of over one hundred individuals, including boys and girls of high school age and men and women from 37 occupations. All of these 576 activities involved rather definitely ascertainable principles and elements of physics. They included things which people generally do for themselves,

such as "Replace burned-out fuses"; things which they often have others do for them, as "Take pictures with a camera of special lens"; and things about which people think, as "Wonder what makes one 'hear the ocean' in a sea shell." Each person indicated the extent to which these activities entered into his life during the past year.

It is on the basis of these data that I arrived at the conclusions which I shall present.



Now, let us study the first graph. Here we find the answers of only the boys and girls pictured. The boys' interests are indicated by the solid line, the girls' by the broken line. The extent to which the activities involving principles from each of the large topics of physics entered into their lives is indicated in per cents. In the graph, columns numbered with Roman numeral I record the extent to which each topic, such as magnetism and electricity, is involved in the activities which people generally do for themselves; the columns numbered with Roman

numeral II record the extent to which each topic is involved in the activities which people often have others do for them; and the columns numbered with Roman numeral III record the extent to which each topic is involved in the things about which people think or wonder.

It should be especially noted that, with the exceptions of sound and light, the boys are always much more affected by physics than are the girls. Note the large per cents in the case of thinking activities, which, by the way, included much the longest list, being made up of 249 out of the 576 activities, or nearly half of the entire list. This thought or natural curiosity phase is one that is given all too little attention in our high school physics courses.

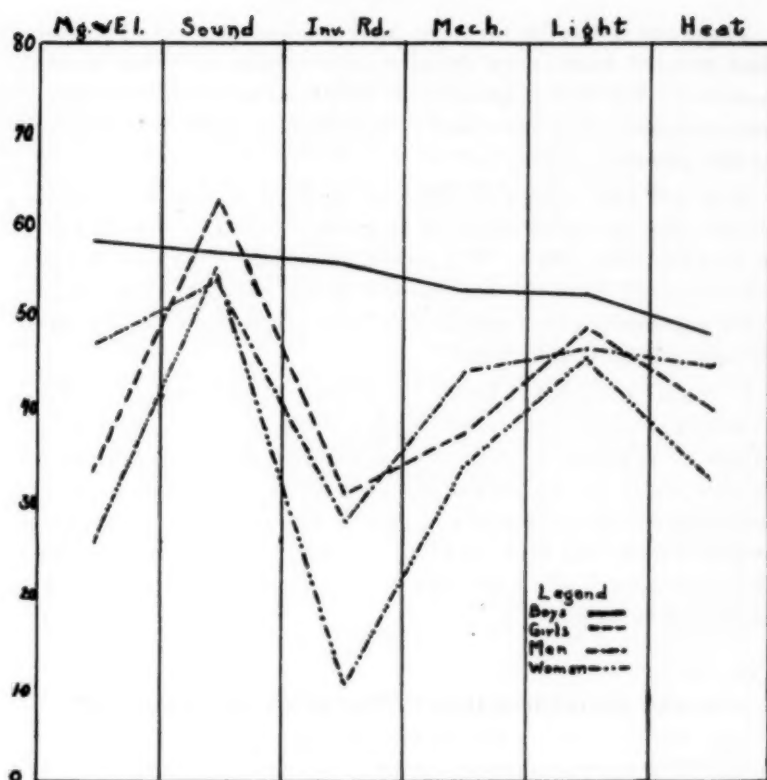
Let us note the order of interest in this respect for boys. It is: Invisible Radiations, Mechanics, Magnetism and Electricity, Heat, Sound, Light. For girls it is: Light, Sound, Invisible Radiations, Heat, Mechanics, Magnetism and Electricity. Almost the reverse of the order for boys.

Now we shall turn to the second graph. Here we have the average of the three types of activities expressed in per cents again. The solid line is for boys, the broken line for girls, the dotted line for men and boys combined, and the dot-dash line for women and girls combined.

Note here particularly the dip in the topic of Invisible Radiations caused both by men and women, due no doubt, to the newness of radio, radium, and the like, and to the intense interest of boys and girls in them but lack of interest on the part of older people who have not yet been reached, despite the enormous amount of publicity which has been given such subjects.

Now I have had to lead you very hurriedly through all of this, and I know that you have not traced every bit of evidence which has led me to the final conclusions, but I think that you have been given enough to see that there is some little foundation for the conclusions which I am about to present. You have seen that there are great variations in the extent to which the various topics of physics enter into the activities of people, that there are wide differences in the interests of boys and of girls, and that the extent to which people think about things that involve principles and elements of physics is very noticeable.

On the basis of the evidence presented, which is the most pertinent and significant, and on the basis of some other considerations which I have not the time to give you now, I would



Degree of interest in the large topics of

H. S. Physics

Graph II

suggest the following order of large topics in a high school physics course:

Boys.

Magnetism and Electricity
Invisible Radiations
Mechanics
Heat
Light
Sound

GIRLS.

Sound
Light
Heat
Mechanics
Magnetism and Electricity
Invisible Radiations

These are not to be taken as final conclusions, but this study does present some very definite data which do point in this direction. Further, it presents at least one aspect of curriculum construction in physics which is worthy of a great deal of study by the physics teacher.

You will find a slightly different account of this same phase of the physics curriculum in *SCHOOL SCIENCE AND MATHEMATICS* for June, 1924. The conclusions there also vary a little but I believe that the conclusions given here are more nearly valid, inasmuch as the matter has been given more study since the writing of that article.

I might add that Chester J. Peters, Supervisor of Science Teaching in the University High School of the University of Missouri, is using the results of this investigation as a basis for further study in the actual teaching of physics. I hope to see some real results published in a year or two as a result of his work, results which will give material assistance to teachers of high school physics, both in the way of a curriculum and in the technique of teaching.

WHAT SHOULD SCIENCE TEACHING ACCOMPLISH?

BY HENRY HARAP,

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For practical purposes, science is concerned with common phenomena which are not self-evident. The field of science, therefore, is very broad. An ingenious teacher need not be limited by the conventional material included in a science course or text-book. It is important that he should choose intelligently such material which the pupil does not already know, which is interesting, and which the pupil is most likely to use in his present or later life. Science should help the pupil to understand such phenomena as he is most likely to need to understand in his present and later life.

The attempt to discover what phenomena the pupil is most likely to need to understand is fraught with many difficulties. There are several kinds of needs which science may meet and one's course of study will be greatly colored by that type of need which one regards as most important. First, there is the need to interpret science as it occurs in the normal reading materials of the average person, such as newspapers, magazines,

fiction, pamphlets, etc. Second, there is the need to increase one's enjoyment by exploration, experimentation, and observation of phenomena. Third, there is the need to satisfy one's natural curiosity about things that surround one. Fourth, there is the need to utilize science in connection with the immediate use of common materials in the pursuit of one's normal activities.

Courses of study in science have been proposed which are based partially or completely upon one of these needs. In the last analysis there is no way of establishing the primacy of these needs. It is impossible to establish finally that science for reading, for enjoyment, for curiosity, or for utility is most important. If a group decides what is most important it is no proof that it is right. It is merely a convenient way of coming to a decision. If an individual decides which is most important it is no proof that it is wrong. In other words what is ultimately included in a science course must be to a certain degree determined subjectively.

The first type of need which may be emphasized in a science course is illustrated by the investigation of Caldwell and Finley who examined over three thousand newspaper articles pertaining to biology and concluded that while not all high school instruction should be directed to the most common topics found, yet it should consider them as part of the legitimate foundation for the construction of a course of study. L. T. Hopkins of the University of Colorado made a similar analysis of newspapers and magazines as a basis of reconstructing the course of study in science in the Denver schools.

The second and third types of need which may be used as a basis for a science course are illustrated by Carleton Washburne who based his book "Common Science" partially upon questions asked by children. The author went into various classrooms, ranging from the fifth to the eighth grade and said: "Are there any questions you would like to ask?" Later he had the children write out their questions. In this way 2000 questions were collected over a period of a year. These questions together with common scientific phenomena reported by normal school students and adult practical applications of science formed the basis of the course. The Caldwell and Eikenberry text in General Science developed in somewhat the same way. The authors collected questions which pupils asked or which seemed to interest them most. The material to answer the questions was not available and it became necessary to write an original text. C. A. Pollock

proceeded to design a course of study by ascertaining the children's interests. From all eighth grade pupils in the city of Columbus he collected 3,500 questions which they desired to have answered in their science study. The questions were grouped under word headings and formed a children's Interest List. It was this list which became the basis of the science course.

From my point of view the most important and the most easily demonstrable purpose which science should accomplish is to help the individual to perform well the most common normal daily activities. This is the fourth type of need which may be emphasized in constructing a science course. I shall enumerate some of these purposes which I discovered in an attempt to analyze the common activities of man as a consumer. The method of the investigation was: First, to gather all the evidence which shows what the people actually do in the process of consuming food, clothing, shelter, and fuel from census reports, direct surveys of the habits of the people, data gathered by government and private agencies, etc. Second, to gather all the evidence which shows what people ought to do from approved standards of consumption of food, clothing and shelter, which have scientific support and are widely accepted. Third, to compare the habits of the people with standards of good living. This procedure resulted in conclusions recommending that certain habits are utterly bad and should be discontinued; that others are poor and should be improved, and that there are some good habits thus far neglected which should be developed. These conclusions became the ends or objectives to be attained by education.

When these objectives of education for effective consumption were organized under the heads of the familiar school subjects, it was discovered that a considerable number, about 207 out of 850, pertained to the subject of science, that is, 207 specific knowledges and skills out of the total of 850 involved in consumption could be classified as science material. These objectives pertained to food, building materials, household articles, household skills, fuels, lighting, heating, and clothing.

I may now proceed to the main purpose of this paper which is to indicate some of the specific purposes which science teaching in the schools should accomplish. We have discovered much about nutrition but we have not really begun to convert what knowledge we have into food habits. The American people

especially need to reorganize their habits of food consumption. The consumption of food for the great mass of people is now governed by custom. Many families in the United States have an income which is not enough to supply the daily food that the human being requires in order to live decently.

From a careful examination of reliable data it appears that the American people do not consume enough vegetables and fruits. On the other hand the nation consumes too much meat. It is evident that our population needs to know the function of the chief nutritive elements and which foods are particularly rich in these nutritive elements. Protein, carbohydrates, mineral salts, these are scientific terms which are taboo in social conversation. Yet they are as vital as chair, window, hat which are uttered without embarrassment or apology.

The total energy requirement for an adult man per day is between 3000 and 3500 calories. A comprehensive survey of 13,000 representative American families in 92 cities showed that from 33% to 74% of the families studied received less than 3000 calories per adult male per day. Do you see why the calorie and the daily energy requirement are vital materials of science study?

Milk is of supreme importance as a food for children and contains all the nutritive elements required by man, yet the per capita consumption per day is .64 pints as compared with the generally accepted standard of one pint. Cheese contains twice as much protein, pound for pound as beef, and its fuel value is twice as great. Yet the per capita consumption of cheese is four pounds per year while the per capita consumption of meat is 180 pounds per year. What has this to do with science? The determination of the nutritive value of cheese is a scientific process and the nutritive value of cheese is a scientific fact. What is the relation of raw milk to condensed milk, to evaporated milk, to ice cream? These are practical scientific questions.

Pound for pound, fish is as nourishing as meat; fish is considerably cheaper than meat; yet the annual per capita consumption of fish is 18 pounds or one-tenth that of meat. As a nation we eat one-third of the quantity of green vegetables that is required for wholesome living and we are even more deficient in our habits of fruit consumption. Do we know the function of the vegetables and fruits in the diet?

The keeping quality of foods is dependent upon definite chemical effects. The conditions to be met may be the exclusion of

moisture or of bacteria, the maintenance of a high or low temperature, the exclusion of light, or the action of a preservative. For each food the chemical action is definite and easy to learn.

The householder and particularly the home owner is confronted by many problems which are explained by scientific principles. In large cities where tenements predominate it is necessary to give special attention to ventilation. In tenements more than half the rooms open on a court. In rural houses ventilation is not a problem of overcrowded rooms nor a lack of windows but rather of stagnant and dust-laden air. Elaborate experiments performed under the direction of the New York State Ventilation Commission show that cool, fresh air stimulates work and the appetite.

Home problems involving the use of household materials are rich in scientific application. Lumber is by far the most important material in the construction of American homes. It is, therefore, useful to know the common varieties of wood used in building construction, their relative durability and their special uses. The properties of the several woods make them specially suitable and economical for the different parts of the house. Brick and clay products are second in importance to lumber. It is important to know the nature and relative merits of brick, tile, hollow tile, terra cotta, etc. Lime, sand, cement and glass are other building materials which involve the application of scientific knowledge.

The study of the common woods which enter into furniture would be especially valuable because of the deceptive trade practices. Data collected by the American Hardwood Manufacturers' Association showed that the furniture of our nation is made of mixed oak, sap gum and red gum and not of mahogany and walnut as furniture advertisements would lead us to believe. If our generation of children learned the truth about the common furniture woods and of the practices of finishing them the future furniture dealers would not dare to flaunt their false advertisements. A study of the durability of the actual furniture bought shows that it is too poor to be economical in the long run. Using data published by the United States Bureau of Standards in an invaluable circular entitled "Materials for the Household" it is seen that nine per cent of the wood used in furniture manufacture is very durable, 35 per cent is durable, 18 per cent is intermediate and 38 per cent is non-durable.

Although it is commonly known that paint is a decorative

material, it is not widely known that paint is a protective and sanitary substance. The average person does not know the chemical nature of paint, stain, and varnish and consequently confuses them in his thought and speech. The chief ingredients of paint and varnish are chemical substances which it is important to know something about. The action of the chief oils used in paint, the nature and action of the chief white and colored pigments, the relation of the chief pigments to lighting, and the action of thinners and driers are other problems involved here.

The use of metals in tools; the chemical properties of brass, bronze, and copper products; the composition, strength and appropriate uses of the various writing and wrapping papers; the common leathers, their treatment, and the nature and durability of imitation leather involve scientific facts of significance. The cleaning and polishing preparations are chemical products which the consumer should understand better. We include here laundry soap, toilet soap, cleanser, tooth paste, shoe polish, furniture and floor polish. The consumer should know the common ingredients of soap, the relative cleansing quality of soaps, the difference between hard soap and soft soap, between hard water and soft water soap, the common adulterants used in soap; the medicated soaps. The householder should have the basic scientific knowledge with which to identify simple preparations which are sold expensively under trade names; to avoid dangers in the use of cleansing and polishing preparations; to know the peculiar chemical properties which make cleaning and polishing preparations particularly appropriate for walls, wood surfaces, metal surfaces and earthenware; to know the important disinfectants such as carbolic acid, bleaching powder, etc.; to identify such common cleaners as borax, sodium carbonate, caustic potash, etc.

The phonograph is a common household instrument. An inquiry made by the Bureau of Research of the National Retail Dry Goods Association shows that customers buy advertised products only. It appears that certain communities cling with superstitious tenacity to the most widely advertised products. The consumer is ignorant of the basic facts concerning the fundamental parts, the motor, reproducer and needle.

In 1920 every second white family owned an automobile. Today the ownership of automobiles is considerably greater. What knowledge does the purchaser have of the relative merits

of the important parts of an automobile? The automobile presents numerous basic scientific problems, which are extremely useful. The radio which is more recent in its development offers similar problems.

In the performance of household skills many simple scientific problems arise which need to be solved. Some of these have been referred to indirectly in connection with the common household materials. Here it should be mentioned that the most important household skills are carpentry, painting, plastering, plumbing, bricklaying, housecleaning, decorating, and gardening. The possibilities of concrete construction have been too much neglected. Its composition, strength, and durability should be more widely known. It is said that 78 per cent of the homes of the country are without plumbing. Plumbing is so definitely related to health that it should become a fundamental factor in the homes of the future. The decorative skills involve some knowledge of the science of color and illumination and the gardening skills involve the practice and knowledge of the elementary facts of agriculture. It should be remembered that many new complex appliances are making their way into the home which are based on simple scientific principles. The rural home faces a particularly urgent need to appreciate the possibility of reducing drudgery by the use of mechanical appliances. A survey of 10,000 rural families in typical localities of 33 northern and western states showed that the average working day for women is 13.1 hours in summer and 10.5 in winter; that on 61 per cent of the farms, water is carried an average distance of 39 feet; that 96 per cent do their washing; that 22 per cent use power to operate household machinery; that 57 per cent use washing machines. The investigator urges the conservation of woman power by investment in a modern lighting and heating system, running water, sanitary improvements, and power machinery.

Of all the technical problems of the consumer the one which the school has neglected the most is that of fuels. The common fuels for domestic purposes are coal, wood, gas, kerosene, and electricity. Coal and gas supply the large part of the fuel energy of the nation. The nation as a whole is unmindful of the existence of a serious fuel problem. It is said that the nation has within its power the saving of over one billion dollars in its energy supply. The most conservative estimate puts the available reserves of coal at 5500 times the present annual consump-

tion. Anthracite coal at the present rate of consumption will be exhausted in 100 years. A committee of the American Association of Petroleum Geologists has estimated that the available oil supply is sufficient to satisfy the present requirements of the United States for only twenty years.

Defective lighting in the home is very common. The data which form the basis of proper management of lighting in the home are so definite, concrete, and convincing that there is no excuse for the present bad practices in the homes of our country. The important factors that determine good lighting are the materials burned, the lighting apparatus used, shades and reflectors, and the color of walls. Concerning each of these factors the consumer should learn the simple technical details.

There is much waste of fuel due to overheating. A knowledge of the most comfortable temperature and a universal understanding and use of the thermometer should reduce the waste. Very few persons understand the relation of humidity to temperature. The installation of a heating system is a problem for 75 per cent of the homes of the nation. What basic knowledge does the average person have to choose intelligently among the open fire-place, closed stove, hot-air furnace, hot-water furnace, steam, or gas? It is possible to determine the most economical heating and cooking fuels when one knows the efficiency of the equipment used, the heat value of the fuel, and the cost of fuel. The first two of these factors are practical scientific matters.

In 1923 there were 13,400,000 customers receiving electric current, 10,500,000 or nearly $\frac{1}{2}$ of the residences in the U. S. were wired and the number of incandescent lamps per customer produced was 38. This indicates the extent to which electricity is used by the people. The number of electrical devices used in the household is increasing rapidly. A knowledge of useful facts of electricity is necessary for intelligent and economical selection and use of electrical equipment.

S. S. Wyer, who is a leading authority on the use of gas, states that of 100 units delivered through the consumer's meter, 15 units are lost through leakage; 68 units are lost through wasteful combustion conditions; and 17 units are actually utilized. Similarly it is estimated that only 25 per cent of the heat in furnaces is actually utilized. The knowledge involved in correcting these wastes includes such technical details as gas pressure, mixture of gas and air, and radiation.

There is much popular ignorance of simple technical facts about clothing which results in stupid and wasteful habits. When the British Board of Trade made an investigation of the cost of living in American towns it observed that clothing does not cost much more in the United States than in Great Britain but is often less durable. The several fibers used in clothing have varying intrinsic strength. The presence of weighting and sizing materials affects durability. The several fibers differ in heat conductivity, in absorption and evaporation, in elasticity, in weight, which factors determine the hygienic value of a garment. What happens to a garment in the process of laundering depends upon the chemical and physical nature of the fiber of which it is made. It is doubtful if there is a man alive who has not had his flannel shirt or woolen socks destroyed by an ignorant launderer. Ignorance of simple principles of color harmony results in the most outrageous color schemes in the clothing of men and women.

Cotton is treated with glycerin for softness; with starch for fulness of finish; with mucilage for gloss; and with china clay for solid appearance. Mercerized cotton is produced by subjecting the yarn to a treatment of caustic soda dissolved in water. In luster, strength, softness, elasticity and affinity for dyes, silk is a superior fabric. Its expensiveness has led to imitations and adulterations such as artificial silk, mixtures of silk and cotton, silk weighted with metallic salts, and cotton yarn dipped in a solution of pure silk. Linen is clean, launders easily, is stronger than cotton, and does not shrink when laundered, is soft, and absorbs moisture quickly. Cotton is often mixed with linen or given a glossy surface and sold as linen. Laboratory experience with cotton and linen and simple tests should help to eliminate the fraudulent practices which exist.

Contrary to popular opinion the most common skins which enter into furs used by the American people are the muskrat, skunk, opossum and raccoon, and not sables, foxes, minks, seals, beavers, and chinchillas for which they masquerade in the retail market. The pelts of animals from warmer zones, such as the woodchuck and the opossum, are sold under names of animals in the colder climates.

Popular ignorance of quality and hygiene of shoes results in a tremendous waste of money and a huge amount of discomfort and suffering. The consumer should know a little about cowhide, kid and goat skin, calf skin, and sheep and lamb skin which

are the chief kinds of leather which go into uppers. The finishing of upper leather is the result of a chemical treatment which often gives the shoe its distinctive name and appearance.

In conclusion, I have attempted to indicate that there are four major purposes which the teaching of science may accomplish: First, to interpret science in the normal reading of the average person; second, to increase one's enjoyment of the environment; third, to satisfy one's curiosity about natural phenomena; and fourth, to utilize science in improving daily life. A course in science cannot avoid being arbitrary in the emphasis that it places on any of these purposes or in any relative adjustment of these purposes. I stated that from my point of view the most important and the most easily demonstrable of these purposes was that of utility. I then proceeded to indicate specific objectives of science instruction which meet the actual needs of the average person with respect to the consumption of food, building materials, household articles, fuels, clothing and with respect to the heating, lighting and household activities.

DOES $FT. \times FT. = SQ. FT.?$

By G. W. MYERS,

The University of Chicago.

To obtain the area of a plane figure meant until the time of John Wallis (1616-1703) to express the ratio of the area in question to some better known area. Thus, the area of a rectangle 8 in. wide by 3 ft. long was often thought of as made up of 8 strips each 1 in. wide and 3 ft. long. Each strip was thought divided into three 1-ft. lengths. The area was then, 8×3 (or 24) *foot-inch* units. A foot-inch unit was a rectangle 1 *in.* wide and 1 *ft.* long. With such a practice, there was of course no need for such a convention as "express both dimensions in the same unit and multiply." So also we might use the rod-foot unit, or the mile-rod unit, just as in measuring other sorts of magnitude than area, we use the foot-pound, and the mile-ton units.

Obviously, if we saw fit in measuring and expressing areas we might use any convenient unit of length in expressing the length of a rectangle and any other or the same unit of length for the side of the rectangle. The direct product would then give the area in what in general would be oblong, or non-square units. The measurer must then know that the unit-area is as wide as

the given unit of width and as long as the given unit of length of the rectangle to be measured. In measurements of area one would first decide what unit-area he desired to use, then express the length of the rectangle to be measured in lengths of the unit-area, and the width of the rectangle to be measured in widths of the unit-area, and finally to multiply. The product must then be understood to have the *name* of the *oblong unit-area*.

Thus, to know how many 4" by 8" brick surfaces will cover a rectangular surface 6' by 8' express the 6'-side in brick-widths (4"-lengths), the 8'-side in brick-lengths (8"-lengths), obtaining 18 by 12, and then the problem is solved by $18 \times 12 = 216$ (brick-surfaces).

All this merely amounts to saying that in mensuration of areas we have first to decide what unit-area we purpose using, express the dimensions of the rectangle to be measured, one in the width-dimension of the chosen unit-area and the other in the length-dimension of the unit-area, multiply the newly expressed dimensions, and give the product the name that corresponds to the chosen unit-name. The naming of the result is no part of the multiplication process, but is done from a common sense understanding of what the problem is. No formal written display of denominate dimension-names throughout the written work should be supposed to guide the pupil in "naming his answer." "Gumption," and gumption alone, guides one in naming the answer.

The important thing to note is that each dimension of the rectangle to be measured, that is, each factor of the product, contributes equally to the character of the unit of the product, that is set forth in the name of the product-unit.

Theoretically, this must be true for one of the outstanding defining features of the operation of multiplication is the *interchangeability of the factors*. In short, it is impossible to multiply a concrete number by an abstract number, as children are commonly taught to do, for such factors are not *interchangeable* in any rational, straightforward sense. We can multiply an abstract by an abstract, and in a slightly modified sense a so-called concrete by a concrete number.

Neither factor of a product is more or less coercive upon or contributive to the name of the product than is the other. Both factors are equally effective, if either factor has any effect at all, on the product. In applications of the operation of multiplication to concrete situations the character of the product

is derived *equally from both factors*, even if the chosen unit is the *ft.-ft. unit*, or the *square foot*.

It is therefore confusing and erroneous, not to say pernicious, to have children learn and try to use such *pseudo* laws as—

1. The product must be of the same kind or name as the multiplicand.
2. The multiplicand must be concrete and the multiplier abstract.

Instead of teaching such fallacious "stuff" for pupils to commit and requiring a parrot-like recital of it back to the teacher as is commonly the practice in our elementary schools, we should be training teachers to teach children that—

1. In application work, we multiply always abstract numbers.
2. We name the answers from a common sense understanding of what we are trying to make multiplication do for us, and not from arithmetic at all.

If we should teach multiplication in this rational way pupils would see no contradiction in such problems as, "How many mile-tons of work is done in hauling 400 tons 100 miles," and "How many foot-pounds of work is done in lifting 40 lb. 12 ft., against gravity?"

Returning again to the mensuration problem, we recall that Wallis first pointed out that the areal problem would be much simplified by always choosing a square unit for expressing area, and then expressing the dimensions in terms of the side-unit of the chosen square unit. Metrical experts and mathematicians have generally followed this practice since Wallis' time. This practice may be exemplified by the work to be done in obtaining the area of a rectangle 3 ft. by 5 ft. thus—

$$3 \text{ ft.} \times 5 \text{ ft.} = 15 \text{ sq. ft.}$$

This involves two things, viz: the operation of multiplying 3 by 5, and the convention that when dimensions are expressed both in the same linear unit, the simplest areal unit to choose is a square each side of which is the common dimension unit.

Good pedagogy dictates that in teaching this technique to children, each of these two ideas should for a time be isolated and practiced separately and thereafter at brief intervals should be brought again into function to resist the operation of the forgetting tendency. Good modern pedagogy also approves sloganized forms for quick recall of essentials of frequently needed ideas as of very high efficiency in child training. Hence, the convention

above cited may be very well sloganized under the forms—

Inches by inches give square inches,

Feet by feet give square feet,

In. \times in. = sq. in.

Ft. \times ft. = sq. ft. etc.

These are merely clever ways of economically and effectively recalling to the child the convention that the unit of area to be used is a square whose sides are the length-unit being used. They happen to be also the forms that are used by men of affairs who deal extensively in areal problems.

We conclude therefore that—

Ft. \times Ft. = Sq. Ft.,

and the like, are at once pedagogical, economical and practical. No more effective form has yet been proposed to replace this sloganized form. No alternative form is in the literature that does not involve serious objection.

Some teachers claim that children can better realize the underlying analysis of the areal problems, through habituating them to the form—

$3 \times 5 \times 1$ sq. in. = 15 sq. in.

Sir Oliver Lodge in his "Easy Mathematics, Chiefly Arithmetic" has made it clear enough to open-minded readers that the form last given is highly confusing to children. American teachers who desire to know the strength of the argument against this artificiality would gain as much from a perusal of the discussion of this point in Sir Oliver's book as did English teachers for whom it was primarily written. This clumsy form, be it said, was not originated by American pedagogues but was derived from English teaching practice, and is fit to rank in learnability with the English system of weights, measures and monetary relationships.

Anyone watching a teacher who has routinized herself to $3 \times 5 \times 1$ sq. ft. = 15 sq. ft. and who is seeking to routinize her class to it will be impressed with the confusion and difficulty it begets. The child does not see that three factors are involved, nor that the use he has to make of the square foot to express his area amounts to multiplying by 1 sq. ft. He knows that 3 and 4 are lengths in feet, and the only mystery is why say the numbers are *nameless* (abstract) when they are plainly named, why they must be regarded as abstract though they are plainly not abstract, if indeed this "abstract-concrete" lingo means anything at all to the pupil. This concreting and abstracting lingo to the

grade pupil is utterly barren and confusing. To "concrete" the multiplicand differently from the way the problem itself "concretes" it and to "abstract" the multiplier merely so that the pupil may use the falsehood "the product must have the same name as the multiplicand" begets the confusion that is too often taken for stupidity in the child. As a rule in any rationally taught arithmetic the product does not have and cannot have the same name as the multiplicand except when the factors are abstract, and then neither product nor factors has any name at all.

Other teachers whose class room experiences have shown them that the form $3 \times 5 \times 1$ sq. ft. = 15 sq. ft. is quite unintelligible to children claim to find a way out by using the form 3×5 sq. ft. = 15 sq. ft. This however is little if any less confusing, so far as real understanding goes, than the $3 \times 5 \times 1$ sq. ft. = 15 sq. ft. The problem plainly gives the child the dimensions 3 ft. and 5 ft., and says nothing at all about sq. ft. for either factor. Why take the unit ft. away from one factor and give it to the other? Why make one factor abstract and the other a different concrete from any number given in the problem? Which number the Peter to be robbed to pay Paul, and why do the "hocus pocus" at all? All these questions are to be answered "in order to be able to use the spurious rule the product must be of the same name as the multiplicand." This is very far from making the already very simple problem

$$3 \text{ ft.} \times 5 \text{ ft.} = 15 \text{ sq. ft.}$$

more easily, or clearly understandable to the child.

Any of the attempts in practical teaching to lug a difficulty in where for the pupil none exists, to avoid teaching him the only thing he really needs to learn here, viz., "finding the area of a rectangle is a case of multiplication," and to evade the slogan—

$$\text{ft.} \times \text{ft.} = \text{sq. ft.},$$

because forsooth some pedagogical wag sees in it the danger that pupils will generalize from it that—

$$\text{dollars} \times \text{dollars} = \text{square dollars},$$

has done actual harm to many a pupil and does harm to the subject always. No matter what some writer or teacher-trainer who for a year or so has given some fleeting attention to arithmetic teaching, may paragraph about the "modern pedagogics" of it, the really teachable and learnable form is—

$$\text{ft.} \times \text{ft.} = \text{sq. ft.}$$

This is true for the simple reason that it is both correct and pref-

erable in practice to such alternative forms as have yet been proposed by the "formalists." We therefore answer the query of our title with an unqualified "Yes."

Finally there is no more difficulty in multiplying "a concrete" by "a concrete" than in multiplying "an abstract" by "an abstract," if the operation of multiplying is properly defined.

A COMPARISON OF SOME TESTS GIVEN IN HIGH SCHOOL PHYSICS.

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The purpose of this investigation is to determine, insofar as the results may show, (1) The relative merits of three so-called objective tests in physics, (2) The relation, if any, between success in physics as measured by these tests and measured intelligence of the group, (3) Whether grouping on the basis of a single test for I. Q. is a reasonable basis for predicting probable success in physics, (4) Whether performance in mathematics test offers a prognosis for probable success in physics.

The method of procedure was as follows: A test of fifty questions, covering the work of the first semester of high school physics, was prepared using the completion type of question. An exactly similar test of the True-False type was made, taking each of the questions of the former test in turn and formulating the same idea to conform to this type. Similarly a multiple choice type of test was prepared. The question and ideas involved correspond, number for number, in the three types. Each of the tests was then broken up into two forms—Form A and Form B. The odd numbered questions constituted form A and the even numbered ones form B. A complete set of the questions is to be found at the end of this discussion.

The purpose of the tests is to measure the achievement of students in the first semester of high school physics. It becomes necessary to grant the validity of the tests. The subject matter covered is that usually covered in the best current high school texts and represents only those major topics upon which stress is laid by teachers and upon which there is a fair unanimity of opinion among teachers and executives, as to their importance. It is necessary to check the reliability of the several tests. It may be remarked that the validity of the tests would not enter into our first problem as exactly the same idea is covered in each of the three types of test under consideration.

Both forms of the completion test were given to each of three sections of high school students in the University High School who had just completed their first semester in the subject. There were sixty-four students and they were given all the time they needed and were told to answer all the questions they were able to answer. The time for the two forms of the test varied from 60 to 100 minutes, that is, all had finished both forms in the latter time. Two days later both forms of the true-false test were given the same students. The greatest amount of time consumed by any student on these two forms was 32 minutes. On the same day both forms of the multiple choice test were given. The maximum time used by any student on these tests was 40 minutes.

From the very nature of the tests, it would seem that there would necessarily be a considerable amount of learning from each preceding test. The student had no information that a second test would follow the first or a third the second, so there was probably a minimum amount of discussion and comparison of results on the first test, and no opportunity was given for such discussion between the second and third testing. If the tests contributed to the learning, one would expect the second to show a better score than the first and the third a better score than the second. This was found to be not the case, so we may disregard any learning value. Again it may be well to point out that this feature would not affect the reliability determination of any one form.

The total number of correct responses to the completion tests was 1391. For the true-false type there was a total of 2164 correct responses. A total of 1908 correct responses was made for the multiple choice type. This represents a gain of 56% on the true-false and a gain of 36% on the multiple choice over the completion.

The reliability of the several tests was determined by correlating the results of form A and form B. The product-moment method was used in determining these ratios. The results in tabular form follow:

CORRELATION FACTORS OF FORMS A AND B OF COMPLETION, TRUE-FALSE AND MULTIPLE CHOICE TESTS.

Test	Correlation Factor
Completion Forms A and B	0.803 \pm .03
True-False Forms A and B	0.52 \pm .06
Multiple Choice Forms A and B	0.67 \pm .047

This table should read, "The coefficient of correlation between forms A and B of the completion test in physics is .803 with a P. E. of plus or minus .03," etc.

The data at once suggests that perhaps the element of chance and the guessing of answers enters into the true-false to a greater extent than in the completion and in both T F and M C to a greater extent than in this completion type. In other words it seems probable that the chance or guessing element has functioned in both the true-false and multiple choice. This seems reasonable in consideration of the number of correct responses. One would expect the same number of such responses in the last two cases or would expect a greater correct response in the last case.

The reliability factor of the completion test is high. Since each form of the test represents the same subject matter, we may regard the factor as .803 with a P. E. of plus or minus .03. It is evident that the other types of test, since they cover the same ground question for question, should have the same or approximately the same high factors—granting equal skill in the formation of the question. The evidence seems to show that the greater the chance and guessing factor, the lower the reliability factor.

A study of the intra-correlations shows the following results:

INTRACORRELATION OF THREE TYPES OF TEST IN PHYSICS. QUESTIONS
DIFFERING IN TYPE ONLY.

Tests	Correlation Factor
Completion—True-False	.41 ± .07
Completion—Multiple Choice	.48 ± .06
True-False—Multiple Choice	.68 ± .05

In these cases the total score made by the pupil in the two forms was used. Here again one would expect to find a higher inter-correlation, since a correct response to a given question requires the same physics information and learning. The data may mean a faulty formulation of the question in some of the forms, or it may point to the guessing effect.

Grouping the students into tertiles on the basis of the total score made on the completion test, we find 24 displacements when grouped on the basis of T-F, and 20 displacements when based on M. C. total scores. The grouping on basis of T-F and M. C. total scores shows a displacement of only 15. The table is given on the following page.

The intelligence quotients of the group of students were obtained from the administration offices of the high school. These

AGREEMENT OF SECTIONING BY THREE TYPES OF PHYSICS TESTS.

Basis of sectioning	No. Placed Correctly	% Incorrectly Placed
Completion—True-False.....	40	37.5
Completion—Multiple Choice.....	44	31.
True-False—Multiple Choice.....	49	23.

figures are based upon a single administration of the Otis Test and the test was given in October of the current school year. The correlations between the three physics tests and I. Q. follow.

CORRELATION OF OTIS I. Q. AND PHYSICS TESTS.

Tests	Correlation Factor
Completion—Otis.....	.45 ± .06
True-False—Otis.....	.32 ± .076
Multiple Choice—Otis.....	.60 ± .05

There seems to be very little relation represented in these figures. One may conclude that, if the tests are valid measures of achievement in physics, the I. Q. as measured by this one test is not a safe criterion for prognosis.

In order that we may study this point from another angle, we have arranged the sixty-four pupils into tertiles on the basis of these I. Q.'s, and determined the resulting displacement for each of the physics tests. The table follows.

AGREEMENT OF SECTIONING BY PHYSICS TESTS AND INTELLIGENCE TEST
—SIXTY-FOUR PUPILS IN PHYSICS.

Basis of Sectioning	No. Correctly placed.	Units of Displacement	% Correctly Sectioned.
Completion—Otis.....	31	36	51.6
True-False—Otis.....	25	44	61.
Multiple Choice—Otis.....	31	37	51.6

In some cases the displacement was two sections. The unit of displacement is taken as a displacement of one group—a displacement of two sections is therefore regarded as two units of displacement.

It is safe to say that the data show no safe criteria for grouping students into ability groups on the basis of Otis I. Q.

In October of the present school year these pupils were given a test in mathematics, which had been compiled by members of the science department of the school. This test included questions involving the common mathematical skills, abilities, etc., which would be needed in physics for successful work. The test

was scored on a point basis. It was given to diagnose the mathematical condition of the student entering the classes at that time. While there was no use made of the results in sectioning the pupils, or for prognosis of probable success, the test was found very helpful in determining what mathematical abilities and skills needed to be taught or reviewed in order to assure reasonable success in physics. It will be of interest here to study the results of this test by making a comparison of the scores made with the records the same students made on the several tests in physics.

For a list of the mathematics questions the reader is referred to *SCHOOL SCIENCE AND MATHEMATICS*, No. 25, P. 837 *et. seq.* The table follows:

CORRELATION OF TESTS IN PHYSICS WITH TESTS OF MATHEMATICS SKILLS AND ABILITIES.

Tests	Correlation Ratio
Mathematics and Completion.....	.74 \pm .04
Mathematics and True-False.....	.66 \pm .047
Mathematics and Multiple Choice.....	.71 \pm .04
Mathematics and Composite (Three Types).....	.75 \pm .036

It is observed from the above table that the mathematical test correlates quite highly with each of the forms of the physics test as well as with the composite of the three. This points to the fact that the possession of these skills, abilities and powers are necessary to success in physics and suggests that knowledge of the extent of these possessions may serve as a basis of classification of students of physics into ability sections. In order to investigate this point, the sixty-four students were sectioned into tertiles on the basis of scores made on the mathematics test. The displacements that are produced by the several types of physics test and by the composite of the three, are shown in tabular form below:

AGREEMENT OF SECTIONING BY TESTS OF MATHEMATICAL ABILITY AND PHYSICS TESTS.

Basis of Sectioning	No. Correctly placed	Units of displacement	% Incorrectly placed.
Math.—Completion.....	46	20	28
Math.—True-False.....	39	33	45
Math.—Mult. Choice.....	39	30	45
Math.—Composite.....	44	26	31

The composite is the total score on the three tests and represents all the correct responses a student made to the entire battery of tests.

From a consideration of the data gathered for this study, the following conclusions seem to be justifiable:

1—The reliability of any form of test in which the guessing element enters to any considerable extent cannot be high.

2—The reliability of the Completion Type test is higher than is that of either the True-False or Multiple Choice type.

3—The I. Q., as determined by a single standard test of intelligence, is not a safe prognosis for success in physics.

4—There is a close correlation between mathematical skills, powers and abilities, and ability in physics.

5—Mathematics tests can be made which will have prognostic value of success in physics.

COMPLETION TEST IN PHYSICS—FORM A.

Fill out the blank or blanks with a word or words which will make an entirely correct statement.

- 1—The smallest particle of chalk that can exist as chalk is called the
- 2—The ability to do work is called
- 3—When we double the density of a confined gas, we the pressure of the gas.
- 4—The two simple materials of which all matter is thought to be made are and
- 5—The specific gravity of any object can be found if we divide its by the
- 6—A body moving under an accelerating force of 10 cm. per second, will move cms. during the first second.
- 7—The greatest height to which water may be lifted by a lift pump is feet.
- 8—The efficiency of a machine is found by dividing the by the
- 9—Density is divided by
- 10—With a hydraulic press which has pistons 10 and 1 inches respectively in diameter, a force of 10 pounds upon the small piston will produce a force of on the larger piston.
- 11—A hydrometer will sink to a depth in water than in gasoline of sp. gr. 0.75
- 12—A body which floats in water with 1-5 of its volume out of the liquid, has a specific gravity of
- 13—If a body is moving under the influence of a certain accelerating force, and moved 20 cms. the first second, the accelerating force was
- 14—If a three pound mass and a one pound mass are dropped from a balloon at the same time, the three pound mass will take times as long to reach the ground as the one pound mass.
- 15—A bullet moving with a velocity of 10 meters per sec., has times as much energy as one twice as heavy and moving with a velocity of one meter per sec.
- 16—Using a pulley system having an efficiency of 80%, and having five strands supporting the weight which is one of 500 pounds and on the movable block, it is necessary to exert a force of pounds to support the 500 pound weight.
- 17—The initial velocity which a ball thrown vertically upward into the air must have, if it remains in the air 6 seconds is
- 18—A freely falling body passes over feet the first two seconds of its fall.

- 19—A force of pounds is needed to balance a weight of 100 pounds on an inclined plane of 60% efficiency which rises one foot in ten.
- 20—When one dyne of force acts upon 2 grams of mass for one second, it moves that second and if the second be the first second, it will move cms.
- 21—Forty centigrade degrees equal Fahr. degrees.
- 22—One B. T. U. of heat energy equals calories.
- 23—If the specific heat of ice is 0.5, it will require calories of energy to change 10 grams of ice at 10c. to water at 0 degrees C.
- 24—The water equivalent of a calorimeter is found by The weight of the calorimeter by The number of calories absorbed by the calorimeter is found by the water equivalent of the calorimeter by the number of degrees change in temperature.
- 25—The zero of the Fahr. thermometer is degrees the freezing point of water at ordinary pressure.

COMPLETION TEST IN PHYSICS—FORM B.

- 1—When 10 grams of force act through 1-2 cm. of space, we say that five are done.
- 2—The name cohesion is given to the between molecules.
- 3—The dyne is the metric of
- 4—If the weight arm of a lever is three times as long as the force arm the is 0.33333.
- 5—One must do dyne centimeters of work per sec. to exert a watt of power.
- 6—The period of vibration of a pendulum 9 meters long will be times as great as that of a pendulum 4 meters long located at the same place.
- 7—We call the kind of energy possessed by a 10-pound weight situated a distance above the earth
- 8—Using a jack screw, one can lift a weight as many times as great as the force used as the is times the
- 9—In a small tube, the surface of water is concave upward because the force of cohesion is than the force of
- 10—A dyne is times as great as a gram of force.
- 11—A bubble of air escaping from a diver's suit at a depth of 68 ft. under water will be times as large when it reaches the surface. (One atmosphere equals 34 ft. of water.)
- 12—If the force of attraction between two bodies is one gram when they are 2 cm. apart, then the force between them is 1-4 gram when they are cm. apart.
- 13—The pressure exerted by an enclosed gas is due to on a unit area.
- 14—The magnitude of the moment of a force is the of the and
- 15—It will take a force of at the end of a uniform 10 foot bar weighing 100 pounds, which has a fulcrum one foot from the end to put it in equilibrium.
- 16—The number of inches in a centimeter is
- 17—If the weight of a body is expressed in grams, and the velocity in cm., per sec., the kinetic energy as determined by the formula $E = \frac{MV^2}{2}$ is expressed in
- 18—A freely falling body, starting from rest, has a velocity of feet per sec. at the end of its second second of fall.

- 19—When a pull of one dyne acts for one second upon a mass of 20 grams it imparts a velocity of cm. per. sec. to it.
- 20—A bullet shot horizontally with a velocity of 100 meters per sec. from the top of a tower 44.1 meters high, will strike the ground meters from the base of the tower.
- 21—The volume of a gas at 10 degrees C. will change to of its present volume when the temperature is 20 C., if the pressure is constant.
- 22—A watt hour means that joules of work are done each second for seconds.
- 23—If a rod is 100 cm. long at 0. C. and 100.8 cm. long at 80 C. the coefficient of linear expansion is
- 24—The relative humidity of the atmosphere is defined as the relation of to
- 25—The zero absolute is that centigrade temperature at which gas molecules

MULTIPLE CHOICE TEST IN PHYSICS—FORM A.

DIRECTIONS: Underseore the answer to the question which you think is the correct answer.

- 1—The smallest particle of chalk that can exist as chalk is: an ore, a molecule, a crystal, an atom.
- 2—The ability to do work is called: power, energy, horse-power, force.
- 3—Doubling the density of a gas: doubles the pressure, makes the pressure $\frac{1}{2}$ as great, makes the pressure 1-4 as great (temperature remaining constant).
- 4—The two simple things of which all matter is believed to be composed are: force and energy, matter and molecules, electrons and protons, compounds and mixtures.
- 5—The specific gravity of a body may be determined by: dividing its mass by its weight, by dividing its weight by its density, by dividing its mass by an equal weight of water, by dividing the mass by the weight of an equal volume of water.
- 6—A body moving under the influence of an accelerating force of 20 cm. per sec. per sec. will go in the first second a distance of: 10 cm., 100 cm., 5 cm., 50 cm.
- 7—The greatest distance to which one can raise water with a lift pump is: 30 inches, 34 ft., 76 cms. 14.7 pounds.
- 8—The useful work which a machine does, divided by the actual work done upon it gives: the efficiency, the mechanical advantage, the per cent of friction, the "effort up."
weight, weight, weight, mass
- 9—Density is:
mass volume weight of water weight.
- 10—A hydraulic press with pistons of 10 and 1 inches respectively in diameter will give to the large piston, when a force of 10 pounds is applied to the small piston: 100 pounds, 50 pounds, 5000 pounds, 1000 pounds, of force.
- 11—A hydrometer will sink to: a greater, a lesser, to the same, depth in water than in alcohol (sp. gr. of alcohol is 0.80).
- 12—A bubble of air escaping from a diver's suit 68 ft. under water will be: 2 times, 3 times, $\frac{1}{2}$ times, exactly one time, as big when it reaches the surface (1 atmosphere equals 34 ft. of water).
- 13—A body moving under the influence of an accelerating force of 20 cm. per sec. per sec. moved during the first second: 20 cm., 4 cm., 10 cm., 400 cm.
- 14—A three pound mass dropped from a balloon will take: three times, 1-3, 1-9, exactly as long, to reach the ground as a one pound mass dropped at the same time from the same place.
- 15—A bullet moving with a velocity of ten meters per sec. has: 10 times, 100 times, 50 times, 25 times as much kinetic energy as a bullet twice as heavy, moving with a velocity of 1 meter per sec.

- 16—Using a pulley system with 5 strands supporting the weight, which is one of 500 pounds, and with an efficiency of 80%, one needs, 100, 50, 125, 80 pounds of force to hold it.
- 17—A base-ball which was thrown vertically upward and which remained in the air 6 sec. had an initial velocity of: 6 times 9.8 meters, 36 times 9.8 meters, 36 times 4.9 meters, 3 times 9.8 meters.
- 18—A freely falling body passes over: 64.32, 32.16, 128.64 feet during the first two seconds of its fall.
- 19—To balance a weight of 100 pounds on an inclined plane of 60% efficiency, which rises 10 feet in 100, requires a force of: 12.5, 16.66, 10, 60, 6, pounds.
- 20—When one dyne acts upon two grams of mass for the first sec. the mass moves a distance of: 2, $\frac{1}{2}$, $\frac{1}{4}$, 1960 cms. that second.
- 21—Forty centigrade degrees equal: 72, 104, 22 2-9, 14.4 Fahrenheit degrees.
- 22—One B. T. U. of heat energy equals: 252, 746, 427, 1-427, calories.
- 23—If the specific heat of ice is 0.5 it requires: 5375, 850, 805, 537.5 calories to change 10 grams of ice at -10C. to water at .0C
- 24—The number of calories absorbed by a calorimeter is determined by: multiplying the weight of the calorimeter by the number of degrees change in temperature, by multiplying the water equivalent to the calorimeter by the number of degrees change in temperature, by multiplying the weight of the calorimeter by its specific heat, by dividing the specific heat into the product of the weight of the calorimeter and the number of degrees change in temperature.
- 25—The zero point on the Fahrenheit thermometer is: 32 degrees above the melting point of ice, 32 degrees below the melting point of ice, the melting point of ice, at ordinary pressure.

A MULTIPLE CHOICE TEST IN PHYSICS—FORM B.

DIRECTIONS: Under-score the answer to the question which you think is the correct one.

- 1—When 10 grams of force act through $\frac{1}{2}$ cm. of distance we call the amount of work done: 5 dynes, 5 dynes centimeters, 5 ergs, 5 gram cm.
- 2—The force acting between like molecules is called: power, surface tension, capillarity, cohesion, adhesion.
- 3—The metric unit of force (absolute) is the: erg, dyne, joule, watt.
- 4—The mechanical advantage of a lever that has a weight arm 3 times as long as the force arm is: 3, 3-4, 4-3, 1-3.
- 5—If one exerts a watt of power he must do: 10 million dyne centimeters of work, 980 times 10 million dyne cm. of work, 980 gram cm. of work, 1 joule of work, 980 dyne of work per sec.
- 6—The period of vibration of a pendulum 9 meters long is: 9-4, 4-9, 16-81, 3-2, as great as that of a pendulum 4 meters long, when both are at the same location.
- 7—A ten pound weight situated above the surface of the earth has: kinetic energy, centrifugal force, potential energy, osmosis.
- 8—With a jack screw the weight lifted has the same relation to the force used as: The radius of the circle in which the force moves has to the pitch of the screw, the length of the lever which works it has to the diameter of the screw, the diameter of the screw has to the pitch of the screw, the circumference of the circle in which the force moves has to the pitch of the screw.
- 9—Water in a small tube has a surface that is concave upward because: surface tension is greater than cohesion, adhesion is greater than cohesion, cohesion is greater than adhesion, adhesion is greater than surface tension.
- 10—A dyne is: $\frac{1}{32.16}$, 32.16, 980, $\frac{1}{980}$ of a gram.
- 11—A body which floats in water with 1-5 of its volume out has a sp. gr. of $\frac{2}{10}$, $\frac{8}{10}$, $\frac{1}{10}$, 5 $\frac{1}{10}$.

- 12—If two bodies 1 cm. apart attract each other with a force of one gram, when they attract each other with a force of 1-4 gram they are $\frac{1}{4}$, 4, 2, $\frac{1}{2}$ cm. apart.
- 13—The pressure exerted by an enclosed gas is due to: gravity, to capillarity, to molecular collisions, to potential energy.
- 14—The magnitude of the moment of a force is: the product of the weight by force, quotient of useful work and force, quotient of force and lever arm, product of force and lever arm.
- 15—In order to keep a uniform bar ten feet long, and weighing 100 pounds and having a fulcrum 1 ft. from the end in equilibrium, it will be necessary to have a force of: 100, 1000, 400, 500 pounds at the extremity of the short end.
- 16—There are: 0.3937 inches, 2.54 in., 3.937 in., 10 inches in 1 cm.
- 17—The kinetic energy determined by substituting in the formula $\frac{MV^2}{2}$
- $E = \frac{\text{—}}{2}$ where mass is in grams and velocity is in centimeters per sec. will be expressed in: dynes, joules, ergs, gram cm.
- 18—A freely falling body starting from rest, has a velocity of: 64.32, 32.16, 128.64 feet per second at the end of the second second of its fall.
- 19—When a pull of one dyne acts for three seconds upon a mass of 20 grams it imparts a velocity of: 3, 60, 20-3, 3-20, 20 cm. per sec.
- 20—A bullet shot horizontally with a velocity of 100 meters per sec. from the top of a tower, 44.1 meters high, will strike the ground: 100-44.1, 300, 4410 meters from the base of the tower.
- 21—The volume of a gas at 10C, will be: doubled, increased 10-273, will become 283-273, 283-293, 293-283 of its former volume when the temperature is 20C.
- 22—A watt hour means that; 10000000 joules, 1 joule, 1000 joules, 10000000 gram cm. of work are done each second for 3600 seconds.
- 23—If a rod is 100 cm. long at 0 C. and 100.8 cm. long at 80 C, the coefficient of linear expansion is: 0.8cm., 80, 0.01, 0.0001.
- 24—The relative humidity of the air is; the amount of moisture in the air, the density of the water vapor in the air, the weight of the water vapor that is in the air divided by the weight that could be present, the relation between the density of the water vapor present and the density of the air.
- 25—The zero absolute is defined: as the centigrade temperature at which there is no molecular energy, the lowest temperature ever obtained, The centigrade temperature at which substances have no volume.

A TRUE-FALSE TEST IN PHYSICS—FORM A.

DIRECTIONS. Put an "X" in the margin, opposite the number of the question, if the statement is true. Put an "O" there if the statement is false.

- 1—The smallest particle of chalk that can exist as chalk is called an atom.
- 2—The ability to do work is called power.
- 3—When we double the pressure on a gas, we double the density if we keep the temperature constant.
- 4—All matter in the universe is believed to be made of just two kinds of material, namely: electron and proton.
- 5—If we have the weight of the volume of water that is equal to the volume of a body, we can find the specific gravity of the body by dividing the first weight by the weight of the body in air.
- 6—A body moving under an accelerating force of 10 cm. per sec. will go ten cm. the first second.
- 7—With a pump, one can lift water to a height of 34 feet.
- 8—The efficiency of a machine is the useful work the machine does divided by the actual work done on it.
- 9—Density is weight divided by mass.

- 10—If the pistons of a hydraulic press are 10 and 1 inch respectively in diameter, a force of 10 pounds on the small piston will produce a force of 100 pounds on the large one.
- 11—A hydrometer will sink to a greater depth in gasoline (sp. gr. 0.75) than it will in water.
- 12—If a body floats in water with 1-5 of its volume out, it has a specific gravity of 0.25.
- 13—A body moving under the influence of an accelerating force of 20 cm. per sec. per sec. moved twenty cm. the first second.
- 14—If a one pound mass and a three pound mass be dropped at the same time from a balloon, the one pound mass will require three times as much time to reach the earth as the one pound mass.
- 15—A bullet moving with a velocity of ten meters per sec. has 5 times as much energy as one twice as heavy moving with a velocity of one meter per sec.
- 16—A force of 100 pounds will just support a load of 500 pounds on a movable pulley of a system of pulleys which has five strands supporting the weight and which has an efficiency of 80%.
- 17—A ball which was thrown vertically upward and which remained in the air six seconds had an initial velocity of 9.8 meters per sec.
- 18—A falling body passes over 64.32 feet during the first two seconds of its fall.
- 19—It requires a force of six pounds to balance a weight of 100 pounds on an inclined plane which rises ten feet in a hundred and which has an efficiency of 60%.
- 20—When a pull of one dyne acts for three seconds on a mass of 20 grams, the mass acquires a velocity of three cm. per sec.
- 21—Forty centigrade degrees equal 72 Fahr. degrees.
- 22—A B. T. U. of heat energy is equal to 427 calories.
- 23—If the specific heat of ice is 0.5, it requires 850 calories of heat energy to change 10 grams of ice at -10 degrees C. to water at 0 degrees C.
- 24—The number of calories absorbed by a calorimeter is determined by multiplying the water equivalent of the calorimeter by the number of degrees change in temperature C.
- 25—The zero point of the Fahr. thermometer represents the temperature at which ice melts under ordinary pressure.

A TRUE-FALSE TEST IN PHYSICS—FORM B.

- 1—When 10 grams of force move through $\frac{1}{2}$ cm. of distance, we say that 5 dyne centimeters of work have been done.
- 2—The force existing between two like molecules is called the force of cohesion.
- 3—The dyne is the absolute unit of force in the metric system.
- 4—When a lever has a weight arm three times as long as the force arm its mechanical advantage is three.
- 5—When one exerts a force of 10000000 dynes through a distance of one centimeter in a second, he is exerting a watt of power.
- 6—A pendulum nine meters long will have a period of vibration 2-3 as great as a pendulum 4 meters long, at the same place.
- 7—A weight of ten pounds situated above the earth is said to have kinetic energy.
- 8—With a jack screw, one can lift a weight as many times as great as the force he uses as the diameter of the circle in which the force moves is times the pitch of the screw.
- 9—The water in a small tube has a surface that is concave upward because the surface tension is greater than the cohesive force.
- 10—A dyne is 32.16 times as large as a gram.
- 11—A bubble of air escaping from a diver's suit 68 ft. under the surface of water in a lake will be twice as large when it reaches the surface. (1 atmosphere equals 34 ft. of water.)
- 12—If two bodies one cm. apart, attract each other with a force of 1 gram, they attract each other with a force of $\frac{1}{4}$ of a gram when they are 4 times as far apart.

- 13—The force exerted by an enclosed gas is due to the force of the bombardment of the moving molecules on a unit of the surface.
- 14—The magnitude of the moment of a force is equal to the product of the force times the length of the force arm.
- 15—If a uniform bar weighing 100 pounds is 10 ft. long and has a fulcrum 1 ft. from the end, it will require a force of 400 pounds at the extremity of the short end to keep it in equilibrium.
- 16—There are 2.54 inches in a centimeter.
- 17—When the kinetic energy is determined by the formula: $E = \frac{MV^2}{2}$,
the answer is expressed in dynes, if the mass is given in grams and the velocity in cm. per sec.
- 18—A freely falling body, starting from rest, has a velocity of 32.16 ft. per sec. at the end of the second second of its fall.
- 19—When a pull of one dyne acts upon a mass of 20 grams for three seconds, the mass has acquired a velocity of three cm. per sec.
- 20—A bullet shot horizontally from the top of a tower which is 44.1 meters high, with an average velocity of 100 meters per sec, will strike the ground 300 meters from the base of the tower.
- 21—The volume of the gas doubles when the temperature doubles, if the pressure is kept constant.
- 22—A watt-hour means that a joule of work is done every second for 3600 seconds.
- 23—If a rod is 100 cm. long at 0 C. and 100.8 cm. long at 80 C. the coefficient of linear expansion is 0.01.
- 24—The relative humidity of the atmosphere is the amount of water vapor in the air at any given time.
- 25—The zero absolute is defined as the centigrade temperature at which molecules have no motion.

CAUSE OF MEASLES.

The cause of measles has been discovered, provided researches reported by Dr. N. S. Ferry of the Medical Research Laboratory of Parke, Davis & Company, Detroit, are substantiated by other investigators. The culprit is a streptococcus that is of medium size, grows in chains, and produces small germ colonies with green halos around them. Dr. Ferry has named it streptococcus morbilli. Using this germ, Dr. Ferry has made an antitoxin which when injected into the patient early enough in the course of the disease has prevented the appearance of the rash. This antitoxin, which is similar to that of diphtheria, has been found to protect against measles when injected into susceptible individuals. The measles toxin Dr. Ferry has made can be used to distinguish between those susceptible to measles in a procedure analogous to the Schick test for diphtheria, according to his claims. Dr. W. H. Park, veteran bacteriologist of New York City Department of Health, who has been working with Dr. Ferry's germ and also that reported as associated with measles by Dr. Ruth Tunnicliff of John McCormick Institute, Chicago, indicated that more research will be needed before conflicts in evidence in various laboratories and clinics can be ironed off.

At present the most hopeful method of combating measles is through the use of convalescent serum made from the blood of those who have had the disease and just recovering. Dr. Park told how because of the limited quantities of this serum available it was being used on those very young children who are likely to contract pneumonia as an after effect of measles.—*Science Service.*

THE RULE OF THUMB.*By **FREDERIC L. ROBERTS.**

The text is: "Divers weights and divers measures; both of them alike are abomination to the Lord." (Proverbs, 20:10.) From the earliest times this has been the preachment and yet in face of the keenest trade competition the world has ever known, progressive peoples in this Radio Age are muddling along with Stone Age tools of trade. To the many who are concerned with elimination of waste in commerce and industry the realization has come with a shock that English-speaking peoples (in other ways so truly efficient) are yet governed in their trade transactions by crude "rule-of-thumb" measures which are survivals of barbarism.

A ROYAL JUMBLE.

Thus Alexander McAide, Director of the Blue Hill Observatory of Harvard University, in his witty articles in the *Atlantic Monthly*, exposes the gigantic fraud of the "customary" standards. The original yard, he avers, was the sacred distance "between the tip of the first King Henry's nose and the end of the royal thumb." An inch may have been, as some assert, the length of an equally regal knuckle-bone; though in the 14th Century it was decreed that three barleycorns round and dry "from the middel of the eare" constitute an inch.

"Our foot is supposed to be the length of an English king's foot—although there were some kings more generously endowed than others both as to feet and understanding!" And so on infinitum.

Since early cave man days, when the tool-making animal, man, first wanted to barter or trade the first tool, he found he needed language. This language in its most primitive form may have been merely a smile or a frown, a picture, a symbol, a sign or gesture; or it may have been (as it became later) the spoken and written words and characters. But it always was of basic commercial importance. It is vital part of the commercial life of human kind; and it if is simple, comprehensible by all, and standardized so as to be intelligible to humankind, it must be a potent factor in commercial development. A very important part of the language of commerce is what is properly called the "language of quantity," or the standard units and divisions employed in determining weights and measures.

With the beginning of the practice of bartering came the need for standard value guides or recognized units for determining worth. At first those things nearest at hand were accepted, the foot, arm (we have the cubit in the Bible which is supposed to be the length of the forearm and hand, i.e., from elbow to finger tip,) etc., etc. Then were adapted to use such things as the "stone," "barleycorn," etc.

As civilization developed, the units and standards became more definite; and soon it became a function of the governing power, whatever it might be, not only to determine and maintain them, but to enforce their use and prevent fraud. The rulers assigned this work to the priests and scientists or wise men of the tribe. And so since early times there has been involved a certain spirit of cooperation for mutual advantage and an exercise of authority to secure not only honesty and equity, but uniformity.

Tribes merged, races were built up, wars were waged, nations came into being. Each and all held to their hodge podge weights and measures until, recognizing the need for greater intercourse, they dealt with one another; then developed standardization, but standardization often on an unsound basis; arbitrary units all; just a conglomeration of "value guides" passed on to future generations.

AMBIGUITY AND CONFUSION.

It is this burden of archaic weights and measures that we have accepted through habit and tradition. Granting a certain quaint Elizabethan oddity to our present clutter of weights and measures, they would look better in a museum rather than in the marts of trade. In them we cherish a collection of antiques. And they cost even more than most antiques, and are fully as useless. The truth is, as Gladstone said, that nobody ever really learned this jumble. Many there are among the business folk of our enlightened English-speaking nations who would do away with this battalion of irregulars. They would array in garb of motley the tricky avoirdupois weight and the stolid Henry yard, truss up the hands and feet, do away with all scruples—and, in short, before the mock court of a Table Round, amid clamorous applause, condemn these clowns of commerce to oblivion.

THE METRIC ADVANCE.

Credit is given to a number for originating the decimal metric plan; to certain French scientists and James Watt among the Englishmen. However, the need was recognized long ago and metric weights and measures came into being through the combined efforts (shall we generously say) of the leading thinkers of a past generation. Since France's adoption of this simple and logical system of weights and measures in 1790 and within the past 136 years, every country in the world but two have come to the general use of "meters, liters, and grams." And not one has turned back! If this is not progress and an indication of the ultimate universal use of this exact system of weights and measures—what is? It took 180 years before Arabic numerals supplanted the old Roman system. And that was at a time when civilization was not so far advanced. The metric system is coming and as Roger W. Babson says: "The world is moving on, and we must not stand still in so vital a field as measurement—the master art which leads all arts and crafts, all industry and commerce, all finance and statistics, and now in all legislation. The gradual adoption of the metric weights and measures is best for the United States of America, and the British Commonwealths."

*Reprinted from *Measurement*, July, 1926.

UNUSUAL FIND OF BORAX IN CALIFORNIA.

Anyone would hesitate to hunt for a borax deposit beneath the featureless surface of sand and gravel of a broad alluvial plain, such as is common in the deserts of southern California. Nevertheless, in 1913 a well drilled in ground of this sort on the ranch of Dr. John K. Suckow, in Kern County, struck colemanite, the principal ore of borax, after penetrating bedrock beneath the alluvial cover. Considerable exploratory work followed this discovery, and the district is believed to be of considerable promise. The claims are now said to have all passed into the control of the Pacific Coast Borax Co.

Little geologic information has hitherto been available regarding this occurrence, but in 1924 L. F. Noble, of the Geological Survey, Department of the Interior, in company with H. S. Gale, had an opportunity to examine a shaft and tunnel then being opened by the Suckow Chemical Co., in the middle of the area in which the deposits occur. It was thus possible to ascertain the character and structure of the rocks that include the borax minerals and to examine one of the deposits that had been freshly cut. The results of this investigation, together with notes on the geology of some neighboring related areas, are set forth in Bulletin 785-C, recently published. A copy may be obtained on application to the Director, Geological Survey, Washington, D. C.

PROBLEM DEPARTMENT

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This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution as on the following pages.

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

CORRECTIONS.

December—Late Solution.

$$(AH)^2 = AF \cdot AE = AM \cdot AC$$

$$(CK)^2 = CF \cdot CD = CM \cdot AC$$

$$(AH)^2 + (CK)^2 = (AC)(AM + CM) = (AC)^2$$

A typographical error has appeared in the note on Problem 888, October issue. Fermat's congruence should be $a^{h-1} \equiv 1 \pmod{h}$.

935. Virginia Seidensticker, Hyde Park H. S., Chicago, Ill.

SOLUTIONS OF PROBLEMS.

936. Proposed by J. E. B., Waco, Texas.

Re-statement of 922 with correction.

Find the sum of the infinite series

$$\frac{2}{1} + \frac{1}{10} + \frac{1}{35} + \frac{1}{102} + \frac{1}{267} + \frac{1}{654} + \frac{1}{1280} + \dots$$

Solved by J. Murray Barbour, Aurora, N. Y.

Reduce the powers of 2 in the denominators of the series to the common denominator, 2^n . Then the numerators form the subtraction series—64, 160, 280, 408, 534, 654, The n th term can be found by multiplying by binomial coefficients.

The "sum" of the series is the limit of the $(n+1)$ th term, divided by the n th term, as n approaches infinity.

$$n\text{th term} = \frac{3n^4 - 62n^3 + 441n^2 + 218n + 168}{12 \cdot 2^n \cdot n(n+1)(n+2)}$$

$$(n+1)\text{th term} = \frac{3(n+1)^4 - 62(n+1)^3 + 441(n+1)^2 + 218(n+1) + 168}{12 \cdot 2^{n+1} \cdot (n+1)(n+2)(n+3)}$$

$$(n+1)\text{th term} = \frac{1}{2} + \dots$$

$$\frac{(n+1)\text{th term}}{n\text{th term}} = 1 + \dots$$

Every term after the first will contain a negative power of n . All of these terms approach zero, as n approaches infinity. Therefore the limit of the series is 1.

937. Proposed by J. F. Howard, San Antonio, Texas.

Problem 925, of the April issue; solutions by any method are desired. Also an elementary solution is desired, which is suitable for High School Pupils.

If a circumscribed quadrilateral be formed by drawing tangents at the vertices of an inscribed quadrilateral, the diagonals of the two quadrilaterals are concurrent.

I. Solved by Walter H. Carnahan, Indianapolis, Ind.

The solution is divided into several parts, which may be used as separate exercises for High School pupils.

The figure QPAB is any quadrilateral inscribed in the circle whose center is C. MWOL is the circumscribed quadrilateral formed by the tangents at the vertices of QPAB. OC is drawn intersecting QP at N,

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IV. Solved by Michael Goldberg, Washington, D. C.

The problem may be solved as a special case of Brianchon's Theorem. "The diagonals of a hexagon circumscribing a conic are concurrent."

Treat each of a pair of opposite sides of the circumscribed quadrilateral as two sides of a hexagon in which the vertex is the point of tangency. Then the line joining these points of tangency passes through the intersection of the diagonals of the quadrilateral. Similarly, the line joining the points of tangency of the other two sides passes through the same point. The quadrilateral formed by the four points of tangency is the inscribed quadrilateral, and the lines drawn are its diagonals.

Also solved by Leonard Carlitz, Phila., Pa; George Sergeant, Tampico, Mexico; and the Proposer.

938. Proposed by W. M. Gaylor, Morris High School, New York City.

In how many ways may n men take their hats so that each has a hat not his own?

I. Solved by George F. Wilder, Erasmus Hall H. S., Brooklyn, N. Y.

Let N_n represent the number of ways in which n men can get the wrong hat. Suppose A chooses hat p , then P may choose hat a , in which case there will be N_{n-2} ways in which all can choose wrong hats. P may not choose hat a , in which case, there will be N_{n-1} ways in which all can choose wrong hats. Since A can choose the wrong hat in $(n-1)$ ways, we have the relation

$$\begin{aligned} N_n &= (n-1)(N_{n-2} + N_{n-1}). \\ \text{Hence, } N_n - nN_{n-1} &= -N_{n-1} - (n-1)N_{n-2} \\ &= N_{n-2} - (n-2)N_{n-3} \\ &= -(N_3 - 3N_2) \\ &= (N_2 - 2N_1) \\ &= (-1)^n, \text{ since } N_2 = 1, N_1 = 0. \end{aligned}$$

Using the preceding relation one readily finds that $N_3 = 2$, $N_4 = 9$, $N_5 = 44$, and so on.

From the above relation we get

$$\begin{aligned} N_n - nN_{n-1} &= (-1)^n, \\ nN_{n-1} - n(n-1)N_{n-2} &= n(-1)^{n-1}. \end{aligned}$$

$$[n(n-1)(n-2) \dots 3]N_2 - [n(n-1) \dots 2]N_1 = [n(n-1)(n-2) \dots 3](-1)^2.$$

Adding, and noting that $N_1 = 0$, gives

$$N_n = n! \left[\frac{1}{2!} - \frac{1}{3!} + \frac{1}{4!} - \dots + \frac{(-1)^n}{n!} \right].$$

II. Solved by J. Murray Barbour, Aurora, N. Y.

This problem is, to an extent, the converse of Problem 883, the solution appearing in the November, 1925 issue. In it, the chance that none of the cards would be in the same position is expressed by $(1 - S_n)$, where S_n is the following series

$$1 - \frac{1}{2} + \frac{1}{6} - \frac{1}{24} + \dots + \frac{(-1)^{n-1}}{n!}.$$

In the present problem the chance that none of the n men gets his own hat is the same as the unfavorable chance in the card problem, namely, $1 - S_n$. The number of favorable arrangements is equal to the chance time the total number of arrangements, or $n!(1 - S_n)$. This may be written given for Solution I. This result may be expressed as $n!$ times the expansion of (e^{-1}) to $(n-1)$ terms.

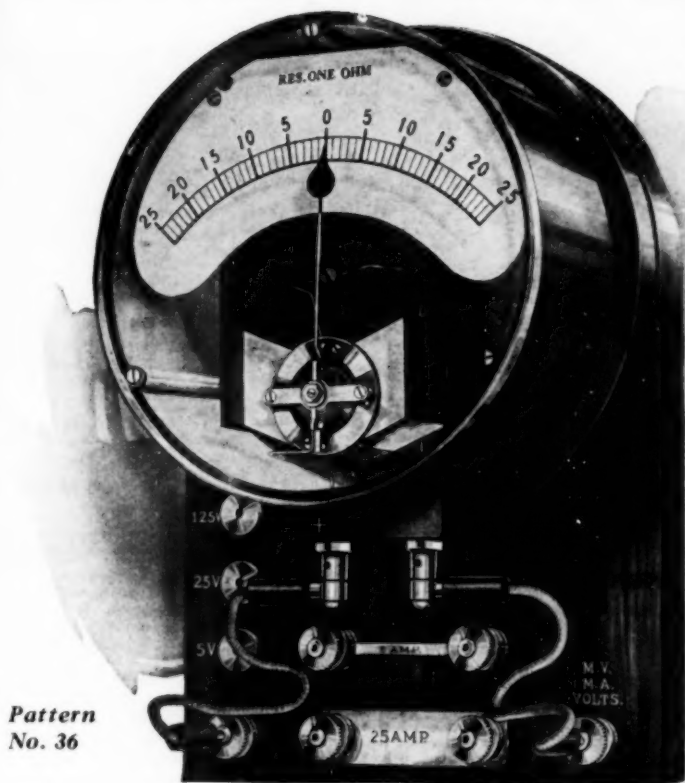
Also solved by J. F. Howard, San Antonio; Texas; Michael Goldberg, Washington, D. C.; and the Proposer. Several incorrect solutions were received.

939. Proposed by Leonard Carlitz, Phila., Pa.

Three circles, O_1, O_2, O_3 , meet in a point P, and O_1 and O_3 meet in A_1, O_2 and O_3 meet in A_2, O_1 and O_2 meet in A_3 . If B_1 be any point on O_1 , other than A_2, A_3 and P, B_2 being the intersection of B_1A_2 with O_2 , B_3 of B_1A_3 with O_3 , then B_2, A_1 , and B_3 are collinear.



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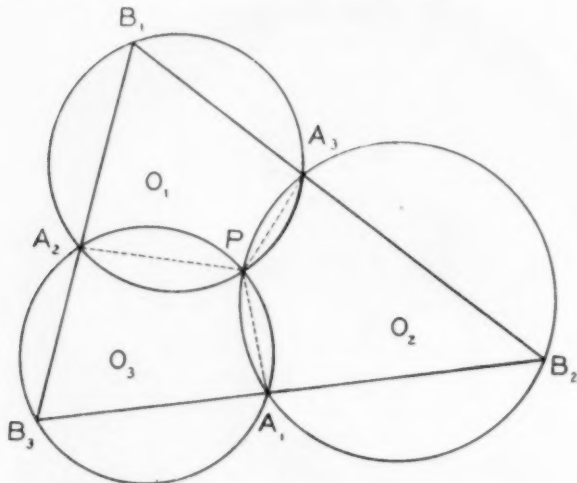
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Editor: Many solutions were received for this problem, all of which were practically the same in method of attack. The solutions, with few changes in wording of statements, are expressed in the following solution.



$$\begin{aligned}\angle PA_1B_2 &= 180^\circ - \angle PA_2B_2 = 180^\circ - (180^\circ - \angle PA_2B_1) = \angle PA_2B_1 \\ &= 180^\circ - \angle PA_2B_1 = \angle PA_2B_1 = 180^\circ - \angle PA_1B_1.\end{aligned}$$

Hence, B_2, A_1, B_1 are collinear.

Solved by *George Sergent, Tampico, Mexico; Michael Goldberg, Washington, D. C.; Carlisle Courtenay, Jr., Columbia, S. C.; J. F. Howard, San Antonio, Texas; N. Altshiller-Court, Norman, Okla.; Arria Murto, Carthage, Mo.; J. Murray Barbour, Aurora, N. Y.; Saluda Reese, Columbia, S. C.; and the Proposer.*

940. *For High School Pupils. Proposed by I. N. Warner, Platteville, Wis.*

A clock gaining three and one-half minutes a day was started right at noon of the 22nd of February: what was the true time when that clock showed noon a week afterward; and, if the clock kept running, when did it next show true time? (From Ray's Higher Arith.)

Solved by the *Editor*.

By comparing the rates per day in terms of half-minutes we find the

gain is $\frac{2880 \times 7 \times 2}{2887 \times 2}$ minutes in seven days. This is $24' 26.4''$. Hence the true time when that clock showed noon a week afterward was 11 hr.: 35 min.: 33.6 sec. (before noon.)

In order to gain 12 hours it would take as many days as $(2880 \times 7) / (2887 \times 2)$ is contained into 720, which is $206 \frac{1}{14}$ days: after Feb. 22, this being Sept. 16, $8 \frac{4}{7}$ min. past 5 a. m.

Three incorrect solutions were received.

PROBLEMS FOR SOLUTION

951. *Proposed by Daniel Kreth, Wellman, Iowa.*

Solve the following equation by Trigonometry.

$$336x^3 + 351x^2 + 62x - 17 = 0.$$

952. *Proposed by C. E. Githens, Wheeling, W. Va.*

Suggested by a story which appeared in a recent issue of the Saturday Evening Post. From a heap of a pieces of money an n th part is taken after one piece is removed. After this had been repeated n times, the remainder is divided into n equal parts. How many pieces of money were there at first?



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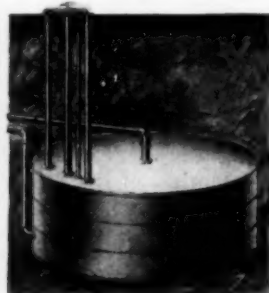
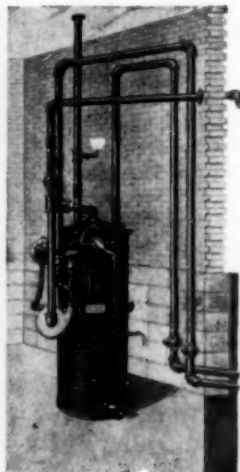
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953. *Proposed by George Sergeant, Tampico, Mexico.*

Given a circle, O , and two lines, L and L' , intersecting in A . From a point X on the circle, the perpendiculars XY and XZ are drawn to L and L' respectively. Determine X so that the line YZ , joining the feet of the perpendiculars, equals a given length, k .

954. *Proposed by J. F. Howard, San Antonio, Texas.*

A letter is known to have come from either London or Madison. On the postmark only the two consecutive letters ON are legible. What is the chance that it came from London?

955. *Proposed by Walter H. Carnahan, Indianapolis, Ind. For High School Pupils.*

$$x^2 + y^2 = 8 - z^2$$

$$x + y = 2 - z$$

$$x^2 + y^2 = z^2$$

A LIGHTNING STROKE FAR FROM THE THUNDER-STORM CLOUD.

Mr. J. H. Armington sends us from Indianapolis the report printed below, which was sent to him by Prof. Z. A. McCaughan, of Bloomington, Ind. The stroke occurred about 1 p. m. on July 23, 1926, in Monroe County; it killed two children.

"I drove to the place referred to and made personal inquiry of people who were within 100 yards of the place. The sun was shining, the nearest cloud seemed to the witnesses $2\frac{1}{2}$ or 3 miles north (toward Clear Creek and Bloomington). They had heard no thunder previous to this stroke and heard only two or three of distant thunder afterward. Their sky stayed clear for two hours afterwards. At the time of this stroke we were having frequent strokes of lightning and thunder here at Bloomington and we had 0.23 inch of rain. Three miles southeast of Bloomington there was a small tornado that broke limbs of trees and carried away anything small that was loose. The lightning was severe. Witnesses near where the children were killed say the lightning traveled horizontally from north to south. It passed three buildings, missing them by about 100 feet, and struck this little house just above the top of the corner foundation post."

The striking of lightning, through clear sky, at points somewhat distant from the region immediately beneath the storm cloud, while relatively rare, occurs probably more frequently than is realized.

During a three-year residence in east-central Florida I observed the phenomenon at least three times. The typical local thunderstorm cloud of the Florida summer grows with great rapidity, and is usually an entity quite unconnected with storms of the same kind that may be developing elsewhere within the observer's field of view. Opportunities for watching the lightning strokes from individual clouds are therefore excellent.

It is my recollection that the distance along the ground between a vertical dropped from the edge of the cloud and the striking point of the bolt was of the order of the height of the cloud base above ground. How foreshortening affected this estimate is of course impossible to say. But it is probably true that the distances were never of the order of 2 to 3 miles, as in the extraordinary case described by Professor McCaughan. In one instance (and I think this was true of all these far flung bolts) the spark seemed to leave the cloud from a point at least halfway up from cloud base to summit, and in this one instance which I recall especially vividly it was about three-quarters of the way.—B. M. Varney in *Monthly Weather Review*.

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ARTICLES IN CURRENT PERIODICALS.

American Botanist, October, Willard N. Clute & Co., Joliet, Illinois. \$1.50 a year, 40 cents a copy. Breadfruit, J. O. Stanciliff. The Need and Making of Local Floras, Donald C. Peattie. The Meaning of Plant Names, Willard N. Clute.

American Journal of Botany, November, Brooklyn Botanic Garden, Lancaster, Pa., \$7.00 a year. Reviews of some perennial Lupines I. Calcarati-Laxiflora, Charles Piper Smith. A Biochemical Study of the Insoluble Pectic Substances in Vegetables, Carl M. Conrad. Growth of Tomato Cuttings in Relation to Stored Carbohydrate and Nitrogenous Compounds, Mary E. Reid.

Condor, November-December, Bi-monthly. Cooper Ornithological Club, Berkeley, Calif. \$3.00 a year. 50 cents a single copy. James Hepburn, a Little Known Californian Ornithologist, Harry S. Swarth. Studies on 1170 Banded House Finches, Harold Michener and Josephine Michener, Pasadena, Calif. The Discovery of the Nest and Eggs of the Western Goshawk in California, Milton S. Ray, San Francisco, Calif. The Viosea Pigeon, Chester C. Lamb, Berkeley, Calif. Range Extensions by the Western Robin in California, Tracy I. Storer, Davis, Calif. A Form of Record for Amateur Ornithologists, Robert S. Woods, Los Angeles, Calif.

American Education, October, Albany, N. Y., \$2.00 a year, 25 cents a copy. Improvement of Instruction, Guy M. Wilson, Boston University. Passing the "Educational Buck," John H. Butler, State Teachers College, San Francisco, Calif. The Supervision of Primary Arithmetic, Emma J. Greenwood, Primary Supervisor, Lawrence, Mass. The Teaching of Religion in the Public Schools, Frances Burnee.

Education, November, The Palmer Co., Boston, \$4.00 a year, 40 cents a copy. Government by the Fittest to Govern, Heber Sensenig, Newport, R. I. The Little Red Schoolhouse Reincarnated, John H. Butler, State Teachers College, San Francisco, Calif. Mental and Educational Tests with Relation to Teacher's Marks, J. F. Santee, Principal of Junior High School, Corvallis Oregon.

Journal of Chemical Education, November, Rochester, N. Y., \$2.00 a year, 35 cents a copy. Chemical Research at the Pasteur Institute, Atherton Seidell, Hygienic Laboratory, Washington, D. C. The Vitamins, H. C. Sherman, Columbia University, New York City. Faraday's Discovery of Benzene, Lyman C. Newell, Boston University. The Structure of Matter. II. The Atom and Radiation, Maurice L. Huggins, Stanford, University, Calif. An Outline of the Dye Industry, R. Norris Shreve, Consulting Chemist, New York City. Qualifications of a Chemistry Teacher, J. E. Wildish, Junior College, Kansas City, Mo. The Application of Colloidal Chemistry to Foods, Frances B. Zimmerman, Sault Ste. Marie, Mich. Teaching Qualitative Analysis, A. T. Bawden, Ottawa University, Ottawa, Kansas. Chemical Equations, J. H. Simons, Northwestern University.

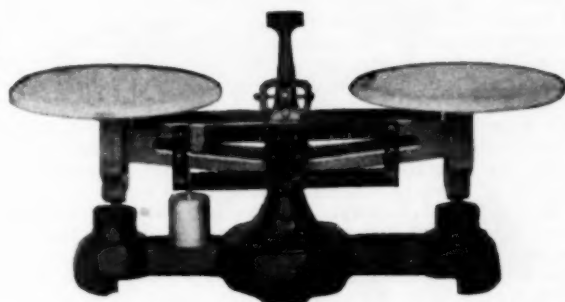
Journal of Geography, November, 2249 Calumet Av., Chicago, \$2.50 a year, 35 cents a single copy. France, Amy E. Ware, State Normal School, Salem, Mass. The Business of Fur Hunting in Canada as an Example of an Extractive Industry, John Q. Adams, University of Missouri. Maps Without Culture: A New Aid in the Teaching of Physiography, Dorothy Wyckoff, Bryn Mawr College. A Normal School Project, George F. Howe, State Normal School, New Britain, Connecticut.

Journal of the National Education Association, December, Washington, D. C. Improving Spelling Through Research, Margaret M. Alltucker. Teaching Respect for Property, Edward O. Sisson, Reed College, Portland, Oregon. The Education Bill Going Forward, William M. Davidson, Pittsburgh, Penn. Physical Education in High Schools, Carl L. Schrader, Boston, Mass.

Mathematical Monthly, October, Menasha, Wis., \$5.00 a year, 60 cents a copy. Origins of Fourth Dimension Concepts, Florian Cajori, University of Calif. Classification of Second Degree Loci of Space, L. J. Paradiso, Ohio State University.

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National Geographic Magazine, November, Washington, D. C., \$3.50 a year, 50 cents a copy. Russia of the Hour, Junius B. Wood. Guatemala, Land of Volcanoes and Progress, Thomas F. Lee.

Photo-Era, November, Wolfeboro, N. Hampshire, \$2.50 a year, 25 cents a copy. A Picturesque River Parkway, William Ludlum, Photographing the Yellowstone, Part IV, Lloyd W. Dunning. Photographing the Elephant-Seal, James B. Herrick. Photography and Its Twelve Immortals, C. B. Neblette.

Popular Astronomy, November, Northfield, Minn., \$4.00 a year, 45 cents a copy. From an Astronomer's Diary, 1925, Frank Schlesinger. Shadow Bands, W. J. Humphreys. The Practical Use of Small Reflectors, William H. Pickering. The Meteor, Rufus O. Suter, Jr.

Science, October 29, Grand Central Terminal, New York City, \$6.00 a year, 15 cents a copy. Ancient and Modern Alchemy, Professor Fritz Paneth, Cornell University. A Suggested Course in Plant Physiology, H. C. Hampton and S. M. Gordon, University of Wisconsin. November 5, Emergent Evolution and the Social, Professor William Morton Wheeler. The Tonga Expedition of 1926, Professor William Albert Setchell, University of Calif.

Scientific American, November, New York, \$4.00 a year, 35 cents a copy. The Excited States of Atoms, Karl T. Compton, Princeton University. Mars Again Our Neighbor, Henry Norris Russel, Princeton University. The Antiquity of Man in America, Harold J. Cook. Can Welding Replace the Rivet? A. M. Candy. Can We Rid City Air of Dust? Dorothy E. Pletcher. The Fossil Bones of Early Man, J. Reid Moir. Classifying the Arthropod, S. F. Aaron.

Scientific Monthly, November, The Science Press, New York, \$5.00 a year, 50 cents a copy. Our Giant Moths, Dr. Austin H. Clark, Smithsonian Institute. Atoms of Energy, Dr. Paul R. Heyl, Bureau of Standards. Pathological Physiology, Dr. Stephen D'irsay, Yale University. The Odyssey of Science, Jonathan Wright, Pleasantville, N. Y. The Conflict Between Science and Religion, Professor Horace B. English, Wesleyan University, Conn. The Eel in Ancient and Modern Times, Ralph C. Jackson. The Murphysboro Tornado, Professor W. O. Blanchard, University of Ill.

School Review, November, University of Chicago Press, \$2.50 a year, 30 cents a copy. The Organization and Functioning of Pupil Opinion in High School Control, Edgar W. Voelker, University of Chicago. Directed Study: Materials and Means, C. C. Hillis and J. R. Shannon, Danville, Indiana. The Continuity Test in History-Teaching, Howard E. Wilson, University High School, Chicago. A Critical Study of the Content of High-School Physics with Respect to Its Social Value, Charles Hoyt Watson, Seattle Pacific College.

BOOKS RECEIVED.

Hygiene, A Textbook for College Students by Dr. Florence Lyndon Meredith, Smith College, Northampton, Mass. Cloth. Pages vii + 719. 21x13.5 cm. 1926. P. Blakiston's Sons & Co., Price \$3.50.

Plane Analytic Geometry, by I. A. Barnett, University of Cincinnati. Cloth. Pages v + 269. 20.5x13.5. 1926. John Wiley & Sons, Inc. Price \$2.00.

Modern Junior Mathematics, Book Two, Revised Edition, by Marie Gule, Assistant Superintendent of Schools, Columbus, Ohio. Cloth. Pages xxxi + 336. 12x13.5 cm. Gregg Publishing Co. 1926.

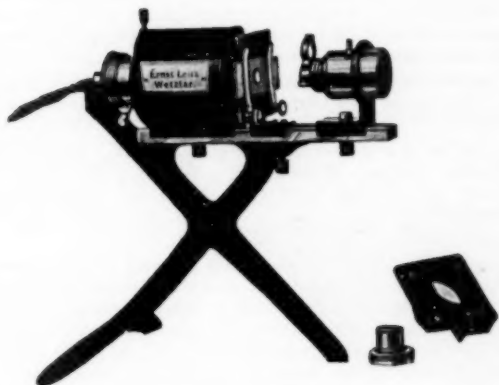
College Entrance and Regents Questions and Answers in Biology. Paper. Pages 159. 13x18.5 cm. Price 50 cents, 10 or more 40 cents each. College Entrance Book Company, Inc., 104 Fifth Avenue, New York City.

Smith's Inorganic Chemistry, by James Kendall, Professor of Chemistry, Washington Square College, New York University. Cloth. Pages v + 1030. 20.5x14 cm. 1926. The Century Co., New York.

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BOOK REVIEWS.

New Physical Geography, by R. S. Tarr and Von Engel, Cornell University. Cloth, pages XI plus 689. 15x23 cm. 1926. The Macmillan Company.

A revision of the late Professor Tarr's *New Physical Geography*, published in 1903. The subject matter has been largely revised and many additions made since the original edition. The illustrations are noteworthy for their close relationship to the text. Sketch maps are numerous and adapted to the discussion of special sections. Seven contour plates in color give details of selected areas. Block diagrams, cross sections and graphs are combined to form a superb collection of illustrative material for use with the text.

Each section is followed by summaries, outlines, questions, suggestions for laboratory exercises and a list of references.

This is a complete text of physical geography and it should create interest in physical geography in the secondary schools and teacher training institutions.

W. M. G.

General Physics for the Laboratory, by Floyd W. Taylor, Professor of Physics, Oberlin College, William W. Watson, Instructor in Physics, The University of Chicago, and Carl E. Howe, Assistant Professor of Physics, Oberlin College. Cloth. Pages vi+247. 15x23 cm. 145 illustrations. 1926. Price \$2.40. Ginn and Co.

As the title suggests this is a text-book as well as a laboratory manual or college classes. Each experiment is introduced by a definite statement of the purpose of the study and a short description of the method to be employed. The mathematical theory involved is developed and all equations and formulae are explained. Very little written description of apparatus is given but in each experiment is included one or more photographs of the apparatus set up ready for operation, the various parts being lettered to correspond with letters in a list of the apparatus used. This plan makes a much more expensive book but a very attractive one and results in a great saving of the student's time. Specific directions are given for adjusting the apparatus, for taking measurements and for making calculations.

The list of experiments contains twelve in mechanics, twelve in heat and molecular physics, fourteen in electricity and magnetism, four in sound and seven in light. The manual may be used with any text, and is worthy of consideration by all teachers of general physics. G. W. W.

A Laboratory Plane Geometry, by William A. Austin, Head of the Department of Mathematics, Venice Polytechnic High School, Los Angeles, California. pp. 404. 15.5x21.5 cm. 1926. Cloth. \$1.40 list. Chicago. Scott, Foresman and Company.

To follow the laboratory method in geometry in arriving at a general truth the author claims that the pupil must take the following steps:

1. Make constructions according to specific directions;
2. Take measurements and perform computations;
3. State the conditions of constructions and the seeming conclusions;
4. Give the usual formal proof to establish the truth in general;
5. State this general truth in the form of a definition or proposition.
6. Solve many different applications to fix in mind the proposition.

This program has been followed throughout the text. The author has made the attempt to have the pupil feel that geometry is as concrete and useful as any other school subject. In this attempt the reviewer feels that he had succeeded remarkably well.

The book is a work of art. The drawings and illustrations are beautifully done. There are numerous exercises. Much material of a practical nature, but not too technical, is found in this text. J. M. Kinney.

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The Teaching of High School Mathematics, by Jasper O. Hassler, Professor of Mathematics, University of Oklahoma. pp. 199. 15x22 cm. Paper. 1926. Published by the University of Oklahoma, Norman, Oklahoma.

This bulletin is divided into two parts. Part one treats of the Primary Concepts of Mathematics with a Historical Sketch of the Development of Algebra and Geometry.

Under this heading the author discusses the Origin and Nature of Mathematics, History of the Development of Arithmetic and Algebra, Fundamental Concepts of the Number System, a Brief History of Geometry, and Now Euclidean Geometry.

Part Two is concerned with methods of teaching mathematics in the Junior and Senior High Schools. The author discusses such matters as Project Teaching, Reorganized Mathematics Curriculum of the Junior High School, Subject Matter and Objectives of Elementary Algebra, Teaching Some Critical Parts of Algebra, Subject Matter and Objectives in the Teaching of Geometry, and Conducting the Recitation.

This work of Professor Hassler sets forth the modern point of view in the teaching of secondary mathematics. Every teacher in this field should secure a copy and read it.

J. M. Kinney.

Calculus, by H. W. March, Associate Professor of Mathematics, University of Wisconsin, and H. C. Wolf, Professor of Mathematics, Drexel Institute. pp. 398. 13.5x19 cm. 1926. New York. McGraw-Hill Book Co., Inc. \$2.50.

This is a revised edition designed to be used as a text in the Junior College. The book is not divided into Differential and Integral Calculus. Integration with the determination of the constant of integration, and the definite integral as a limit of a sum, are given immediately following the differentiation of algebraic functions. One of the noteworthy features of the book is the fact that many important applications of the calculus occur early and constantly recur. Thus the authors exhibit to the student "the bond that unites the experimental sciences." J. M. Kinney.

Modern Plane Geometry, by Webster Wells, author of a series of Texts on Mathematics, and Walter W. Hart, associate Professor of Mathematics, School of Education, University of Wisconsin. pp. 322. 14.5x19.5 cm. 1926. Boston. D. C. Heath & Co.

This Geometry is the third in a sequence of geometries which have been used extensively and over a long period of time in the high schools of the United States. The first was Wells' Essentials of Geometry which, published a generation ago, was one of the pioneers in the attempt to make geometry a thought provoking subject. The second was Wells and Hart's Plane Geometry (1915), which is well known to geometry teachers of the present generation. The present text is an outgrowth of the former and embodies the experience gained in teaching the subject during the past ten years.

Among the features of this text deserving attention are the following.

(1) There is a minimum course which includes all the theorems indicated as fundamental by the College Entrance Requirements Board. These theorems are marked by a star, as in the Board's list. The other theorems of the minimum course also all appear in the list of the Board.

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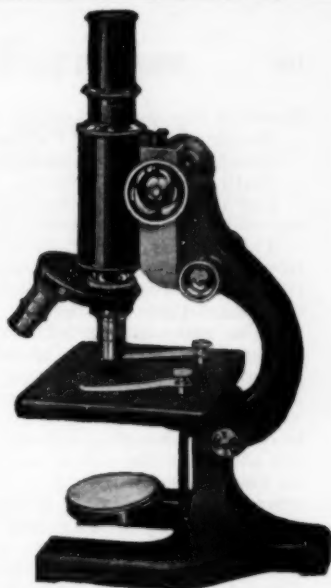
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Standard Service Arithmetics, Book Two, for grades five and six, by F. B. Knight, G. M. Ruch, College of Education, University of Iowa; and J. W. Studebaker, Superintendent of Schools, Des Moines, Iowa. pp. 547. 14x19 cm. 1926. \$0.96. Chicago. Scott, Foresman and Company.

The authors announce that this is the first of the forthcoming standard service arithmetics. Books I and III are to be published within a year.

This book is a reflection of the attempt being made at the present time to put the teaching of arithmetic and secondary mathematics on a scientific basis. The authors make the following statement in regard to this significant piece of work.

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Junior High School Mathematical Essentials, Ninth School year, by J. Andrew Drushel, Assistant Professor of the Teaching of Mathematics, the School of Education, New York University, and John W. Withers, Dean of the School of Education, New York University. pp. 314. 14.5x19.5 cm. 1926. Chicago, Lyons and Carnahan.

This is the third book of a series which interprets the modern movement in the teaching of secondary mathematics.

The following features are noteworthy.

1. Arithmetic computation is stressed.
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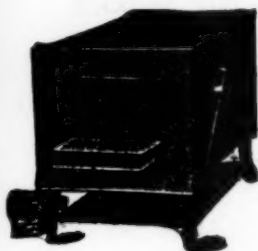
J. M. Kinney.

WHAT DAY IS IT?

Erratum—Vol. XXVI, p. 842. For line 21 from the top of the page and the 4 lines following read:

Of course the revised rule relating to leap years has to be used with this method. Thus, for January and February the characteristic is diminished by 1 for years 00, 04, 08, 12, 16, 20 and 24, years exactly divisible by 4, with this exception; for the modern calendar, if the year 00 represents a century year, then the year characteristic is diminished by 1 for January and February, only if the century number proper is exactly divisible by 4. For the old calendar there is no exception in the case of year 00.

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ASSOCIATION OF SCIENCE TEACHERS OF THE MIDDLE STATES AND MARYLAND.

The following program was given on Nov. 27 at the University of Buffalo, Buffalo, N. Y., at the sixth annual meeting of the Association of Science Teachers of the Middle States and Maryland, in conjunction with the Association of Colleges and Secondary Schools.

9:15 a. m.—Room 305, Foster Hall, University of Buffalo

President—Dr. Joseph M. Jameson, Vice-President, Girard College, Philadelphia.

Secretary-Treasurer—Miss Elizabeth W. Towle, Baldwin School, Bryn Mawr, Pa.

Topic—THE OVERCROWDING OF SUBJECT MATTER IN SECONDARY SCHOOL SCIENCE COURSES.

Paper—"The Important Objectives of Secondary School Sciences," Professor Albert P. Sy, Department of Chemistry, University of Buffalo.

Reports—(a) Committee on Biology, Dr. Edward E. Wildman, Director of Division of Science, Philadelphia Public Schools, Chairman. (b) Committee on Physics, Dr. Earl R. Glenn, Department of Science, Lincoln School, New York City, Chairman. (c) Committee on Chemistry, Dr. Jesse E. Whitset, Department of Chemistry, DeWitt Clinton High School, New York, Chairman.

Discussion.

Address—11:00 a. m.: "The Evolution of Industry as Related to the Evolution of Scientific Knowledge." Dr. Robert E. Rose, Director of the Technical Laboratory, E. I. du Pont de Nemours & Company, Inc., Wilmington, Del.

Business Meeting.

At the close of the meeting the following resolution was adopted by the Association:

RESOLUTION ON FREEDOM OF TEACHING.

WHEREAS, There have been legislative enactments in some states seeking to restrict the teaching of certain subjects;

AND WHEREAS, The extent of human knowledge is such that it is often impossible to reach a wise conclusion as to the merits of different studies, or as to what is true or false in any particular field unless one has devoted many years to its study;

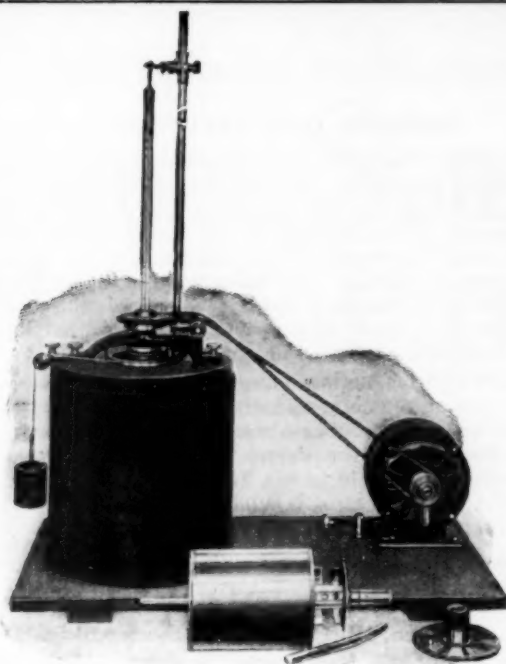
BE IT RESOLVED, By The Association of Science Teachers of the Middle States and Maryland at this its meeting, Nov. 27, 1926, in Buffalo, N. Y.

THAT the first object of school teaching in any given science must be to present fundamental scientific truth in the clearest, simplest and most convincing manner, and as generally accepted by experts in that science.

The following officers were then elected for the ensuing year: President, Dr. Charles E. Dull, Newark, N. J.; Vice-President, Dr. M. Louise Nichols, Philadelphia, Pa.; Secretary-Treasurer, Miss Elizabeth W. Towle, Bryn Mawr, Pa. Members of the Council: Mr. Henry R. Hubbard, Plainfield, N. J.; Dean Winifred J. Robinson, Newark, N. J.; Mr. J. E. Whitsit, New York, N. Y.

Motion was made and carried that the retiring president become *ex-officio* member of the council.

Supervisor of thrift is a new position created this year in the schools of New York City by the board of education. The position carries a salary of \$4,000 a year. Duties of the supervisor will be to stimulate thrift activities in the schools and coordinate the work of savings banks with the public schools.



MECHANICAL EQUIVALENT OF HEAT APPARATUS

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SMALLER THAN ELECTRON.

New evidence that there is another world of almost infinite minuteness, beyond the electron which only recently replaced the atom as the smallest thing in the universe, was brought forward by Prof. Felix Ehrenhaft of Vienna University at the meeting of the Association of German Natural Scientists and Physicians. Prof. Ehrenhaft's data were obtained by means of a new and highly powerful apparatus for ultra-microscopic examination devised by himself, which makes possible the observation of particles far below the limits of ordinary microscopic visibility, floating freely in a gaseous atmosphere in a magnetic field.

He observed in this magnetized sub-microscopic field the behavior of globular bits of gaseous selenium with diameters of only one two-hundred-fifty-thousandth of an inch. Their rate of drift, under the influence of the magnet indicated that the electric charges they carried were less than the equivalent of one electron. This would indicate, according to Prof. Ehrenhaft, that the electron is subdivisible and therefore that something smaller than the electron exists.—*Science Service.*

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